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ART. XIII.—*Biographical Memoir of the late François André Michaux;* by ELIAS DURAND.*

FRANÇOIS ANDRÉ MICHAUX was born on the 16th of August, 1770, at Satory, a royal domain situated in the vicinity of Versailles, which, for several generations, had been intrusted by the Crown to the administration and management of his ancestors. He was the only son of André Michaux, who, with Catesby, Clayton, Bartram, Kalm and Walter, was one of the pioneers of botanical explorations in the North American regions. His mother Cecile Claye, was a daughter of a rich farmer of Beauce. She died, eleven months after her marriage, leaving behind her, a son, the subject of this notice.

Of the early life of François André Michaux, I have not been able to collect much information. It is probable that he was brought up on the farm of Satory in the practical school of his father, and of one of his uncles, upon whom devolved, after the departure of the former, the sole management of this extensive royal estate. It may be inferred also from his writings and instructive conversation, that his collegiate education had not been neglected.

His father, whose history is inseparably linked with that of his son, had devoted all his life to the progress of agriculture and the sciehces; his main ambition had been to effect something

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that might redound to the advantage of his native country, and, with this view, he had early turned his attention to agriculture, the advancement of which, he had soon perceived, could not be more securely attained, than by enriching its domain with such products of foreign climes as were unknown to his own country, and susceptible of acclimation. In order to accomplish his object, he determined to visit new regions, possessing climates similar to that of France, and to bring back thence such of their productions as might prove of advantage to his native land.

To effect that purpose, he prepared himself by a proper course of studies, and by devoting his particular attention to the science of Botany, under the great Bernard de Jussieu. He first visited England; he next made several explorations in the mountains of Auvergne, and in the Pyrenees, and afterwards in Spain. He next embarked for Persia, in the capacity of Secretary to the French Consul at Ispahan, but, in reality, for the sole purpose of exploring that country, then almost unknown to scientific men. From 1782 to 1785, he surveyed the whole of the Persian provinces, between the river Tigris and the Euphrates, and returned to France, with an extensive collection of specimens, and a large quantity of seeds of every kind.

During the absence of the elder Michaux, the French government had been agitating the important question of introducing into the forests of France, such exotic trees as would be calculated to increase the national resources, with respect to naval constructions. The information which had been received from the United States in this regard, had been exceedingly encouraging, and Michaux, who had just returned from Asia, was chosen for that particular errand, with instructions to procure, for the royal nurseries, all the young trees, shrubs and seeds he could possibly send. In consequence he made all proper dispositions, and embarked at Lorient on the 25th of August, 1785, taking with him his son, then only fifteen years of age, and a journeyman gardener of the name of Paul Saulnier, of whom I shall speak hereafter. They landed at New York on the first of October following.

At this remote period of time, I am altogether without record as to the movements of young Michaux, immediately after his landing on our shores. The only source where I expected naturally to obtain information, was the manuscript journal in which his father was in the habit of registering the daily incidents of his eventful life, and which had been deposited by his son in the library of the American Philosophical Society. Unfortunately, this journal has become incomplete, through the absence of three of its fasciculi, containing the years 1785, 1786 and 1790, which were lost in the shipwreck of the elder Michaux on the coast of Holland. In the fasciculus of 1787, young Michaux's

name appears for the first time on the date of May 6th, as accompanying his father in his exploration to the sources of the Keovee river. In the next spring, he is seen again with him, journeying into the interior of Florida. He is afterwards mentioned several times, as being retained at the Charleston Nursery, either on account of ill health, or intrusted with the management of the plantation, during the journeys of his indefatigable and ever-moving father.

In the further perusal of the manuscript, I learn, at the date of the 20th of September, 1789, that, on that day, his son walking along the road, was hit by a man shooting at partridges, and that a grain of shot had penetrated his left eye, below the pupil. From that date to December following, he occasionally speaks of the state of his son, of the treatment applied to his case, and, especially, of the great despondency of mind in which the patient had fallen, from the apprehension of losing his eye. But, here again we arrive at the third lost fasciculus, and I cannot ascertain the final result of the accident, nor at what time, precisely, young Michaux returned to France.

His return must have taken place in the first three months of 1790, for, in the manuscript of the following year, on the 17th of January, the elder Michaux acknowledges the receipt of a letter from his son, dated Paris, April, 1790, but nothing more is said about the wounded eye. To that accident, which is not generally known, may be attributed the partial deprivation of sight with which Michaux was afflicted.

Young Michaux therefore reached his country at the very outbreak of the French revolution, in which he is said to have warmly sympathized with the republican party. Such a course was not, perhaps, expected from one who had been brought up on a royal domain, and was, to a certain degree, indebted to royal munificence. But, on the other hand, how could the feelings of this generous and impressible young man be otherwise enlisted? His exalted patriotism, his ambition to serve his country, his frank and bold temper; his love of liberty, which he had imbibed in this free and happy land—all these together must have raised his spirits to a high pitch, in conjunction with the vexation he experienced when, on his return, he scarcely found a few remnants of the several hundred thousand young trees, which his father and himself had reared, in their American nurseries, and sent home for the particular benefit of his country. One half of these had been given away by the Queen to her imperial father of Austria; the rest had been squandered among the minions of the court, to embellish their grounds, or shamefully neglected in the royal nurseries of Rambouillet.

In the mean time, the elder Michaux was continuing his explorations in North America. He travelled in all directions,

over more than three thousand miles, during the eleven years which he spent on this side of the Atlantic. While thus actively engaged, the political storm, raging in his country, had brought on immense changes in his situation. France ruined by royal profligacy; invaded by famine; deluged with the blood of her best citizens; convulsed by civil war and fighting, single-handed, with the whole of Europe, could no longer afford to pay her naturalists abroad. Consequently, Michaux was forgotten, and ceased gradually to receive his salary. After having borrowed money on his own account; after having sacrificed a portion of his own, and of his son's fortunes, he found himself under the necessity of returning to his country. Unfortunately he was shipwrecked on the coast of Holland, and, after having lost the best part of his immense collections, he arrived in Paris on the 26th of December, 1796, after an absence of eleven years and four months.

On his arrival in his native land, the elder Michaux occupied his time in the cultivation of the vegetable treasures which he had forwarded from the United States, and in arranging his materials for the *history of the North American Oaks*, and for his *Flora Boreali-Americana*. In these various labors, he was assisted by his son, who, in the meantime, was studying medicine under the celebrated Corvisart, and attending the clinical lectures of Désault, chief surgeon of the Hotel Dieu, with the view of returning to the United States, and devoting himself to the practice of medicine; but such was not his destiny!

Neither the retired habits of a student, nor the easy and monotonous life of a Parisian abode suited temperaments like those of the two Michaux. Such men needed activity and change of scene, even with toils and perils. Both were animated with the same spirit of enterprise, with the same conviction that their efforts, employed in other directions, could afford more benefit to their country; hence, they were endeavoring, through the influence of their numerous friends, to infuse their views and projects into the minds of their fellow members of the Central Society of Agriculture, and of the ministers of Napoleon, then First Consul of the French Republic.

In this finally they both succeeded. The elder Michaux accepted a commission of naturalist in the scientific expedition led by Captain Baudin, and bound to the Australian seas, on condition, however, that he would be permitted to remain at the Isle of France, if he desired so to do. Disgusted with Baudin's haughty manners and want of courtesy to the scientific corps, André Michaux abandoned the expedition at Mauritius, where he remained six months, and then started for the island of Madagascar, which, he thought, would afford him better opportunities of advancing the science of botany, and making himself more useful to his country.

After sundry explorations along the coast, he established a botanical garden at Tametave, in which he planted all the trees and plants which might be objects of usefulness or curiosity. The climate, unfortunately, was exceedingly unhealthy, and trusting too much to his good constitution, and habits of exposure, he neglected the proper precautions, was taken sick with fever, and died at the end of December, 1803.

François André Michaux, on his own account had not remained inactive. Aroused by the example of his father, and now fully arrived at manhood, he could not look back to the unfinished work of his father in the United States, without becoming alive with the most ardent desire to achieve the object which they both had in view. Conversant with several States of the Union, confident in his own experience and abilities further to serve his country, he was, on his side, earnestly soliciting a commission to the United States.

This opportunity was at last afforded him through the celebrated De Chaptal, then Minister of the Interior, who feeling dissatisfied with the result of the nurseries of New Jersey and Charleston, since the departure of the elder Michaux, and thinking more benefit would accrue from the appointment of native correspondents in the principal seaports of the Union, consulted François A. Michaux in the matter, and appointed him to effect those objects. He gave him instructions, at the same time, to sell the properties, when he should have forwarded home all the trees and shrubs remaining in the two French nurseries above mentioned.

Michaux, highly gratified, set out immediately for Bordeaux, at which port he embarked for Charleston, with the same captain, and on the same vessel that had brought him home thence, some ten years previous. After a short and pleasant passage, he landed at his place of destination, on the 9th of October, 1801. He occupied himself almost immediately, and during the following winter, in sending to France the trees and shrubs of the nursery, and this part of his instructions being fulfilled, he embarked for New York on the same errand.

As soon as the season became favorable, he began his herborizations in New Jersey, and along the banks of North River. In these explorations, he discovered several new species of Oaks and Hickories, the acorns and nuts of which he sent to France in abundance. He had also the opportunity of determining with more accuracy, the botanical characters of the Black Oak (*Quercus tinctoria,*) one of the largest trees of the American forests, and, also, one of the most valuable for the good quality of its wood, as well as for its dyeing properties.

He next visited Philadelphia, where he had the pleasure of becoming acquainted with some of her most celebrated men,

among whom he mentions the Rev. Dr. Collin, Dr. Benj. S. Barton, Messrs. Vaughan, Peale, Wm. Bartram, &c. He visited with great satisfaction, the botanical garden of the last mentioned gentleman, and the magnificent green houses of Mr. Wm. Hamilton, which contained a rich collection of exotics, principally New Holland plants. His attention was more particularly attracted by the latter gentleman's romantic grounds, called Woodland, wholly planted with every American tree and shrub that could withstand the severity of a Philadelphia winter. Then, finding he had a few months to dispose of, he took advantage of this circumstance to visit the states of Kentucky and Tennessee, about which he had so frequently heard his father speak in the most enthusiastic terms.

Accordingly, he set out from Philadelphia, on the 27th of June, 1802; passed through Lancaster, Columbia, York, Carlisle and Shippensburgh; then crossing the Alleghany Mountains, he reached Pittsburgh in ten days, travelling alternately in stage, on horse-back and on foot. He left Pittsburgh on the 14th of July, on foot, for Wheeling, and there purchased a canoe to descend the Ohio river, in company with an American officer of the name of Craff. In three days, they reached Marietta, and, on the tenth day, they landed at Limestone, now Maysville. From that place, he travelled alone to Lexington, which he left on the 10th of August for Nashville.

Michaux remained in Nashville four weeks, which were employed, principally, in herborizations around the town and along the banks of the Cumberland river. On the fifth of September, he set out on his journey back to Charleston, by way of Fort Blunt, West Point and Knoxville, which latter place he reached on the 17th, after stopping several days at the Falls of Roaring River, to explore the beautiful country around. From Knoxville he travelled to Greenville, and thence to Jonesborough, the last town of Tennessee. On the 21st he began crossing the high ridge which divides the State of Tennessee from North Carolina, and after two days of the most toilsome journey through the mountains, he reached the farm of old Davenport, who had been formerly his father's guide in that rugged region.—There he remained a week, for the double purpose of resting and conversing with him about his dear father, who, shortly after, on the inhospitable coast of Madagascar, died a victim to the climate and to his zeal for the progress of science. On the second of October, Michaux reached Morgantown, two hundred and eighty miles from Charleston, and arrived in the latter city, on the 18th, by way of Lincolntown, Chester, Winsborough, and Columbus, after having travelled over eighteen hundred miles in three months and a half.

Such was François André Michaux's exploring journey to the Western states, of which he published a very detailed account, two years afterwards, in a work entitled "*Voyage à l'Ouest des Monts Allegheny, &c. &c.,*" During this journey, he did not merely devote his attention to botanical pursuits; but, with his usual habits of observation and extraordinary sagacity of mind, he diligently inquired into the state and modes of agriculture; the nature of the different soils; their particular vegetable productions, and the commercial relations existing between those remote regions and the Atlantic cities. He ever afterwards felt a considerable pleasure in relating the episodes of this long and toilsome journey through these regions, then but thinly settled, and yet the abode of the roving Indian tribes.

He spoke with enthusiasm, and in terms of unreserved gratitude, of attentions of which he was the object; his name was a passport which insured to him a most hearty welcome, and every assistance from those who had known his father, and had received from him seeds for planting or instructions in farming. To the new settlers he was always provided with letters of introduction, which procured him the same good reception. Every where he was hailed with manifestations of respect for the memory of his father, and with unanimous expressions of a desire to be useful to the son in any way within their power.

Michaux remained in Charleston until the first of March, 1803, when he embarked again for France, in the same vessel on board of which he had sailed from the port of Bordeaux, eighteen months before, and landed at that port on the 26th of the same month. On his arrival in Paris, he made every effort in hastening the publication of his father's "*Histoire des chênes d'Amérique,*" which had been printed in 1801, but the plates of which had not yet been completed. He attended also to the publication of the "*Flora Boreali-Americana,*" under the supervision of Claude Richard, an eminent botanist and a superior writer. Both these works were finally announced to the scientific world in the years 1803 and 1804, and were eagerly expected by those who took an interest in the vegetable productions of North America.

In the latter year, Michaux published his "*Journey to the West of the Alleghany Mountains,*" and the following year his memoir "*Sur la Naturalisation des Arbres Forestiers de l'Amérique du Nord.*" In this memoir, addressed to the Central Society of Agriculture of Paris, of which he was a prominent member, he endeavored to prove the great advantage which might accrue to France from the acclimation of better trees than those which her native forests actually possess, and of such, principally, as might well succeed in soils too poor for any of the French trees to thrive therein. In support of his opinion, he pointed out the swampy lands of France, as producing no wood of any value, whilst sim-

ilar lands in America are covered over with noble and valuable trees, such as the red Elm, Willow, Oak, white Cedar, white and black Cypress, &c. He, likewise, pointed at the sandy, and certain cretaceous soils of France, as giving growth to nothing but dwarfish and insignificant pines, while the equally arid lands of the southern states produce an abundance of the live Oak, a tree exceedingly valuable in naval architecture, and which might also well succeed in the sandy maritime soils of the southern departments of France.

Besides these advantages, Michaux proposed to increase the number of forest trees,—which, in France, attaining the height of thirty feet, is limited to thirty-six, eighteen of these forming the bulk of the forests, and seven only being employed in civil and naval constructions—whilst he alone had observed in the North American forests as many as one hundred and forty species of similar height and utility.

The means proposed by Michaux to attain these desiderata, were simply "to send a naturalist to the United States, with the mission to collect seeds and young trees, and to forward the same to the national nurseries of France." His propositions were forcibly supported in a report made to the Central Society of Agriculture by Messrs. De Perthuis, Correa de Serra and Cels, and he was, finally, intrusted with this mission, under the special patronage of the Duke De Gaëte, then minister of finance and for the account of the Administration of the Forests.

He, subsequently, embarked at Bourdeaux, on the 5th of February, 1806, in a vessel bound to Charleston. After being three days at sea, they were boarded by the British man of war Leander, Commander Witheby, who, suspecting the vessel to be laden for the account of French merchants, sent her to Halifax, there to be disposed of by the court of Admiralty, which would decide whether she was a legitimate prize, or should be liberated. Of all the passengers, Michaux was the only one ordered on board the Leander, where he remained during a cruise of forty-three days, after which they reached the Bermuda Islands. While in port, he was permitted freely to go ashore, and had thus the opportunity to make some interesting observations, the details of which he addressed to the Professors of the Paris Museum of Natural History, in a memoir entitled "*Notice sur les Iles Bermudes et particulièrement sur St. Georges.*"

Michaux was finally released, and permitted to sail for the United States, which he reached towards the end of May. Beginning his explorations at the district of Maine, where the winter is as rigorous as in Sweden, though ten degrees farther south, he travelled over all the Atlantic States as far as Georgia, where the heat during six months of the year, is as great as in the West Indies. Besides a journey of 1800 miles from northeast

to southwest, he made five explorations into the interior of the country:—The first, along the rivers Kennebeck and Sandy; the second, from Boston to Lake Champlain, crossing the States of New Hampshire and Vermont; the third, from New York to lakes Ontario and Erie; the fourth, from Philadelphia to the rivers Monongahela, Alleghany and Ohio; the fifth, from Charleston to the sources of the Savannah and Oconee rivers. In travelling along the sea-coast, he visited the principal dock-yards, with the view to examine the timber employed in ship-building; he also entered in all the work-shops where wood was worked into forms. As the knowledge of which he was in need was principally in the possession of artizans, he accordingly consulted the most skillful workmen, and by means of a series of questions, previously prepared, he collected a mass of valuable information.

In his different journeys to the interior, he paid particular attention to the trees that formed the bulk of the forests, with reference to the nature and uses of their woods, or as objects of commerce between the different states, or of exportation abroad. He ascertained the sources of the different barks employed in tanning, inquired into the quality and price of the various woods used for fuel, and formed a complete collection of polished specimens of the species employed in cabinet work or otherwise. In a word, the range of his observations was unlimited, and they could not fail to interest exceedingly the people of the United States, as well as Europeans, and to become one of the main points of the splendid work which he published, almost immediately after his return.

Michaux remained nearly three years in the United States, diligently employed in his arduous task. During his residence, he formed many valuable acquaintances. Besides the late Muhlenberg, Hamilton, Barton, Hosack, Alex. Wilson, Eddy, &c., he was on terms of friendship with others still living, among whom I may mention Dr. John Francis of New York and Major LeConte. Michaux was elected a Member of the American Philosophical Society on the 21st of April, 1809; and we have a proof of the value in which he held this honor, by the handsome provision made in favor of this institution, in his testament, bearing date of May 30th, 1852.

I should fail in my duty towards one, who was the companion and helpmate of the two Michaux, if I omitted here to mention his name. This is the humble Paul Saulnier, the same journeyman gardener who, in 1785, had accompanied them to this country, and was intrusted with the care of the New Jersey nursery. François Michaux never spoke of him but with feelings of respect and affection.

"Originally of France," says Dr. Francis in his eloquent discourse on the Natural Sciences, "his early life was absorbed in practical horticulture, as an experimenter in vegetable physiology, and as one of the subordinates of the Jardin des Plantes. Here, he had instilled into him the principles of the *ordines naturales*. by their author, de Jussieu. Shortly after, he was selected for his botanical attainments, to accompany the elder Michaux to this country. He proved serviceable as a collector. By royal means, Louis XVI, by whose patronage Michaux was authorized to procure American productions, a plot of ground in New Jersey was appropriated as a suitable garden for rearing and preserving plants and trees, mainly designed for the institutions of France.

In this sequestered place, Paul, with the exception of occasional excursions to New York and to parts adjacent, passed the remainder of his days. Here he was visited by the younger Michaux, Pursh, Douglas, Bradbury and other foreign naturalists who reached our shores. Poor Wilson, the Ornithologist, often found shelter within his humble dwelling from the lowering sky and tempestuous storms, and often I have heard Michaux enlarge on the refreshing enjoyment of Paul's hospitality. Paul was a sort of Sir Oracle with them; and his responses were heeded by all who sought practical knowledge in natural history. Paul, I believe, may be estimated the first, as to time, who without much pretension, inculcated among us the classification of Jussieu; and the arboriculturist may perhaps be now, for the first time, informed, that to him are we to assign the introduction into this country of the Lombardy poplar. Paul holds a place in the progress of botanical pursuits not unlike that enjoyed so long by the venerable Wm. Bartram, though I should be reluctant to assign to him a place as conspicuous as that of our philosophical traveller.

Let Michaux speak of the goodness of his heart and of his disinterested philanthrophy: "Paul was so exclusive in his attentions to his avocations, that hardly any other subject than trees and plants ever found entrance into his mind. To the day of his death, he considered his little circumscribed residence as still the property of his royal master; and ignorant of the vicissitudes of political revolution, reluctantly gave credence to the fact of the decapitation of his bountiful, but unfortunate King. Paul now lies in the Hackensack churchyard; his tomb-stone records not half his excellence."

On Michaux's return to Paris, he presented himself before the Central Society of Agriculture, to which he was mainly indebted for his mission to the United States, and there gave an account of his voyage, of the various tasks he had performed, and of the flattering results which had been already obtained:—From the

seeds which he had forwarded during his absence, more than two hundred and fifty thousand young trees had already sprung up, which were fairly promising to accomplish, in succeeding times, the objects contemplated by him, and confidently expected by his fellow members of the Society of Agriculture, who appointed a committee to report on the success of his voyage. Correa de Serra, chairman of that committee, in a most flattering report, highly complimented Michaux on the faithful execution of his trust, and for the importance of the services he had rendered to his country, he called forth a vote of thanks.

During the two years following his return, Michaux was actively employed in the publication of his great work: "*Histoire des Arbres Forestiers de l'Amérique du Nord*," so anxiously expected by all who took an interest in the Flora of the United States, and in the observations of one so well versed in agricultural pursuits. The first volume appeared in 1810; the second, in 1812, and the third, in 1813.

This magnificent work, illustrated by 144 copper plates, designed by the two Redouté and by Bessa, and engraved by such eminent artists as Gabriel, Renard, Boquet, Bessin, and Dubreuil, was translated into English by Augustus L. Hillhouse, Esq., and published in Paris in four volumes by Charles D'Hautel (1817–1819) under the title of "*North American Sylva*," with the addition of several plates and some new observations by the author. Mr. Wm. Maclure purchased the plates in Paris, and brought them to this country. To this circumstance is owing the publication of two American editions, which are likely, soon, to be followed by a third. The first, was issued at New Harmony, Indiana, 1842, and the second in this city, in 1852, with notes by J. J. Smith, Esq. Mr. Nuttall, soon after, published, on Michaux's plan, an additional *Sylva Americana*, describing and illustrating as many as one hundred and twenty trees, mostly unknown to his predecessor, indigenous to the far west regions, Oregon and California included.

Of this splendid work of Michaux, the author of an article on the botany of the United States, published in the thirteenth volume of the North American Review, remarks: "It is the plan of Michaux's history of our forest trees, to unite the advantages of a work strictly botanical and one relating to the useful arts; but, especially, to collect all the scattered details which books or experience could furnish him, with respect to the application of various kinds of woods to the purposes of life. Botanical descriptions can easily be made or found; but, in order to ascertain their useful properties, it was necessary to consult artisans in almost every branch of practical mechanics, to frequent dock-yards and work-shops in which wood was employed, and in short, to gather information from every attainable source. From these

inquiries Michaux had obtained a most extensive collection of curious and important facts, which rather belonging to the application of botany than to botany itself, are nevertheless essential to the complete knowledge of the plants of the United States; for, besides the commercial and practical uses of our trees, we have a very perfect account of the inflorescence, fructification, growth and botanical habit of them individually considered, as also many interesting facts with regard to them taken together as composing forests."

In a letter, dated October, 1852, addressed through Mr. Isaac Lea, to the President of the American Philosophical Society, Michaux expresses himself in the following words, with regard to his *Sylva Americana:* "The science of botany was the principal object of my father's explorations in North America, and the *Flora Boreali-Americana* was the result of those explorations. As for me, I took another view of the vegetable kingdom, whilst in your country—a view more limited and less scientific, it is true; but, perhaps, more generally profitable to the farmer and land-holder, as well as to that class of society, so numerous in the Northern States of the Union, who employ wood in so many different ways. I do not consider my *Sylva Americana* as complete as it might be: thus, for instance, I have omitted several species which grow in lower Lousiana, and in the two Floridas. In the second place I have described and figured some trees that are deficient in the flowers and in the fruits. Had circumstances permitted, I would have returned to the United States, and, in a new edition have corrected the errors, and filled up the omissions. I should thus have been able to present to the American nation, a work worthy of her great name, but now that I have arrived at a very advanced age, nearly 83 years, I can do nothing more, in this respect, than to express my regrets, and the hope that some native arboriculturist may complete my researches on the plan which I have adopted. The publication of such a work would be attended with much benefit to the country, and afford particular honor to him who would undertake it."

After the appearance of his great work, Michaux devoted all his attention to his favorite pursuits—the cultivation and propagation of trees, presenting a special object of public utility. Intrusted with the administration of a large estate belonging to the Central Society of Agriculture; experimenting largely in sylviculture on the extensive plantations of Mr. Delamarre, and owning himself a country place near Pontoise, he never ceased until his death, to be actively employed in experiments on arboriculture, either suggested by himself or others.

Michaux had retained in this country a few correspondents, who sent him occasionally new supplies of seeds, and through a letter furnished by one of these gentleman, I had the gratification to become acquainted with him in the autumn of 1824.

When living in Baltimore from 1816 to 1824, I formed an intimacy with a French gentleman of the name of Leroy, who had known Michaux in this country, and had been since in correspondence with him. This Mr. Leroy, who was himself an excellent arboriculturist, having been earnestly solicited by his friend to send him all the seeds and young trees which he could procure in the vicinity of Baltimore, applied to me, as a fellow botanist, to assist him in this undertaking. We, therefore, went to work together in earnest, during the autumn of 1819, rambling into the woods with a negro boy, climbing and beating Oaks, Maples, and Hickory trees; uprooting the shrubs and young trees that fell in our way, and collecting seeds of every sort. The result of our campaign filled up several large boxes which were forwarded to Michaux, in the early part of the winter.

When I visited Europe in 1824, Mr. Leroy favored me with a letter of introduction to his friend, recommending me as his co-laborer in the collections which had been forwarded to him from Baltimore, some years previous. This letter did not fail insuring to me a hearty welcome at the hands of Mr. Michaux. I saw him frequently, and breakfasted with him at his winter quarters in Paris, on the place St. Michael, which was then a market for garden vegetables and fruits. We seldom sat at the breakfast table, without having previously taken an inspection round through the stalls where fruits and vegetables were sold, and he was pleased to point out to me the rarest and most beautiful with a passing notice on their origin.

Mr. Michaux was extremely desirous to show me, in detail, his fine nurseries, especially those which contained his Maryland trees, to "*contemplate*" the result of the troubles and fatigues which they had cost me, but the weather was so unfavorable, during the whole season, that I could visit but one of them, which I found wholly planted with Maryland Oaks, and covering an extensive plot of ground. Though the young trees, then devoid of their foliage, had suffered much, the second year, from the depredations of a herd of swine that had trespassed upon these grounds, they still appeared vigorous and promising, and are, I suspect, the very same trees that are now (as I see by the Paris papers) adorning the Quai des Tuilleries, and some of the new Boulevards of the French metropolis, under the denomination of *American Oaks thirty-six years old.*

In acknowledgment of the service I had thus rendered him, Mr. Michaux presented me with a copy of the French edition of his magnificent work, beautifully bound in three volumes, and containing a double set of plates, the plain and colored.

Mr. Michaux's person was tall, strongly built; but not corpulent. His complexion was fair; he was slightly pock-marked,

and possessed prominent features. His light blue eyes had a peculiar expression which startled me at first. His countenance was stern and cold on first approach; but it smoothed off and brightened gradually, as he spoke and became more familiar; his utterance, in the beginning somewhat slow and cautious, became rapid and impressive, and his conversation gay and even humorous. All his manners were quite simple and unaffected, frank and lively—they were altogether those of an open-hearted country gentleman, in whose presence, young as I was at the time, I could feel neither embarrassment nor shyness.

I do not think that, after this interview with Michaux, his position and pursuits underwent much change. To the very last day of his life, he was fortunate enough to retain his health and his remarkable activity of body and mind. The main point of his arboricultural experiments, was to turn to advantage those lands, called heaths, which in France alone, do not cover less than two millions of acres, and were considered as utterly sterile. Through forty years of experiments, performed by him on the large demesnes belonging to the Central Society of Agriculture, and to Mr. Delamarre, he has ascertained that such lands could be improved and rendered productive by the cultivation of certain resinous trees, which succeed well in such soils. Of all the American and European pines with which he has experimented, Michaux gives the preference to the Russian Pine, *Pinus sylvestris*, which, in his letter to the President of the American Philosophical Society, above mentioned, he recommends warmly to the particular attention of the agriculturists of the Northern and Middle States of the Union.

With the view to render the scarcity of wood, under which this country is beginning to suffer, through the rapid and improvident destruction of the native forests, Michaux recommends also to the American people the cultivation of bushy or spreading trees, producing copses, or *Taillis*, to which he has applied a special mode of culture, more rational and more favorable to the development of vegetation, and, consequently, more profitable to the land-holders.

We are informed by the same letter, that Michaux was then preparing for publication a work in which he intended, succinctly, to develop his ideas on those interesting subjects, and to lay open the results of his observations and practical experience, for the particular benefit of the farmers and land-holders of the United States.

Michaux's last days were thus passed tranquilly, dividing his time between his favorite occupations of arboriculture, and the society of a few friends, among whom, the most intimate were President Seguier, Messrs. Macarel, D'André and Vilmorin. Louis Philippe himself, who had known him in this country,

never ceased to show him the greatest esteem and affection. He was always happy to see some transatlantic acquaintance. All the Americans, who have seen him in Paris, or at his country residence of Vauréal, can testify to the urbanity of his manners, and to the cordiality with which he received his visitors. In conversation with Americans, nothing afforded him more pleasure than the subject of this country. He listened with amazement to the wonderful accounts of its progress, of the rapid increase of its population, of its wealth and resources, of its success in war and in diplomacy. The names of new cities and innumerable towns, located on sites which, in his time, were still covered with the native forests; the mention of multifarious rail-ways, extending their arms in all directions and encircling the whole country in an immense net-work of iron; the speedy steam travelling by land and water, which would have rendered his long and painful journeys so short and so easy; in fine, the electro-magnetic telegraph, another offspring of American genius —all these wonderful achievements elicited from him the greatest amazement and the most emphatic exclamations: Mon Dieu, Mon Dieu, est il possible!

He felt proud to mention that he had been one of the first steam navigators, and boasted of an early acquaintance with Fulton, whom he met at Albany in 1807 under the following circumstances: He was then returning to New York city from his exploration to the lakes Ontario and Erie, and intended to take passage in a packet boat for New York; but seeing an advertisement of a steamboat to depart the same morning, he had the curiosity to examine her, and he determined to take passage on her. Strange to say, he and a Frenchman who accompanied him, were the only passengers on board; it was the first trial trip. Fulton was on board, and, as might be supposed, between two such men, speaking equally well the French language, an intimate friendship was formed, which continued through life. The ardor of this friendship on Michaux's part, was proved by his devotion to Fulton's memory.

Michaux, having found in Paris a model, in clay, of a bust of his friend by Houdon, bought it and caused it to be put in marble by the best artist he could find, at the cost of 1000 francs. He obtained permission afterwards from the Government to have it placed in the Marine Department of the Louvre, near that of Papin, who had done so much for steam.

Michaux's turn of mind was also literary. Besides his great work on *the North American trees, his journey to the west of the Alleghany Mountains* and the memoirs already mentioned, he published, in 1831, an essay *on the Planera crenata;* in 1852, a memoir on the *causes of Yellow Fever in the United States,* and another one *on the culture of the Vine.* He may have left also, at

his death, some unpublished papers, among which is probably the memoir alluded to in his last communication to the President of the American Philosophical Society. This communication dated, as I have said above, Vauréal near Pontoise, October 24th, 1852, was particularly intended to inform the President and his fellow-members that, desirous of giving the American nation a testimonial of his heartfelt gratitude for the hospitality and assistance which his father and himself had received in this country, during the course of their long and toilsome journeys, he had made testamentary provisions in favor of the Society, with the view to afford the means of promoting the progress of the science of Sylviculture in the United States.

This testament which Michaux had intrusted to the care of a gentleman of this city, Mr. Isaac Lea, whom he had consulted in the matter, was deposited four years ago in the archives of the Philosophical Society; but was not to be opened until after his death. This was done, consequently, on the 20th of October last, by the Recorder of Wills of the city of Philadelphia. By this document, he bequaths to the American Philosophical Society, the sum of fourteen thousand dollars, for special purposes connected with the particular object of his constant aspiration, "The progress of agriculture with reference to the propagation of useful forest trees." By the same instrument, he likewise endows the Society of Agriculture and Arts of Boston, with the sum of eight thousand dollars for similar purposes.

Michaux's demise was made known to the American public by Prof. Asa Gray in the columns of the American Journal of Science, vol. xxii, p. 137. It had been communicated to his lady, by a friend of Mr. Michaux, who thus relates the circumstances of his death: "I have to speak to you of the death of our good friend, Mr. Michaux. He was carried off with frightful suddenness by a stroke of apoplexy, on the 23d of October, 1855. He had been occupied the whole day, planting American trees, and he himself directing his journeymen. He withdrew from his work in good health, dined moderately, but with good appetite. He went to bed as usual, and fell asleep. At about one o'clock in the morning, his wife heard him move about and calling. She instantly rose from her bed, and ran to his apartment. He was still struggling on the floor, when she entered his room; but, on reaching him, she found that he had breathed his last. Physicians were called in immediately, but all in vain, life was totally extinct. He died at the age of eighty-five years."

Michaux left no issue. He had lived single to an advanced age, when quite suddenly, he became tired of celibacy, and changed abruptly his condition, by marrying a relative of his, who, for a long time, had been the manager of his house, his

attendant in sickness and companion in his solitude. They lived most happily together, and at his death, he left her a comfortable provision for the remainder of her life. Mr. Michaux was in easy circumstances, but by no means rich. To his title of Chevalier de la Légion d'Honneur, he added, those of Correspondent of the French Institute, of Member of the American Philosophical Society, of the Central Society of Agriculture of Paris, of the Society of Agriculture and Arts of Boston, &c., &c.

ART. XIV.—*Investigation on the Rock Guano from the Islands of the Caribbean Sea;* by WM. J. TAYLOR.*

THOUGH much has been written and published on the Columbian guano of the Caribbean Sea, (which is also termed phosphatic guano, native super-phosphate of lime, &c.,) I have considered the subject not entirely exhausted, and for some time past have been paying especial attention to its composition, besides endeavoring to gather all possible information regarding its mode of occurrence. To Dr. D. Luther, president of the Philadelphia Guano Company, I am particularly indebted for his kindness in furnishing me with material for the investigation from the various groups of islands, and for information regarding its occurrence. To Dr. F. A. Genth I am also indebted for allowing me to make the investigation in his laboratory.

The guano rock is found on islands northeast and north of the coast of Venezuela in the Caribbean Sea, and belonging to that republic; the islands form groups or keys composed of one hundred or more small islands, inhabited principally, and indeed almost solely, by water fowl, who resort there in immense numbers for laying their eggs. Mr. Cassin informs me that the birds are those commonly known as gulls, pelicans, and cormorants; these have been the instruments by which the immense deposits of guano have been formed. But what the process has been is a problem not yet fully solved.

The Columbian guano is a hard rock, consisting of two distinct portions; the outer exterior crust, consisting of a white, and frequently reniform coating, which, in places where it is not decomposed, has a polished surface not unlike enamel; it is composed of concentric layers, each of which is about two or more lines in thickness. The entire outer crust forms but a very small proportion of the whole rock; a carefully selected portion of this has been analyzed, which had not undergone any apparent decomposition, and upon which the enamelled surface was well preserved. In some portions the reniform surface is dis-

* From the Proceedings of the Academy of Natural Sciences of Philadelphia, March, 1857.

tinctly marked, and it resembles to a certain extent in its appearance the menilite of Menil Montant near Paris; the concentric layers composing it are well marked, and when they are fractured or cut across, an appearance is presented not unlike some varieties of agate.

The following is the result of an analysis:—

(I.)

2·0266 grammes	ignited lost	0·1640 grammes	gave	13·03	p. c.
" "	Ag	0·0274	" chlorine	0·44	"
" "	CaO, SO_3	0·0419	" sulphuric acid	1·93	"
" "	CaO, SO_3	1·9965	" lime	40·64	"
" "	$2MgO, PO_5$	0·1654	" magnesia	2·93	"
" "	$2MgO, PO_5$	1·1753	" phosphoric acid	37·15	"
" "	residue	0·0111	" residue	0·55	"
" "	NaCl	0·1231	" soda	3·23	"

Loss by ignition,	13·03	per cent.	Oxygen ratio,	
Chlorine,	0·44	"	"	
Sulphuric acid,	1·93	"	" "	1·15
Phosphoric acid,	37·15	"	" "	20·82
Lime,	40·64	"	" "	11·55
Magnesia,	2·93	"	" "	1·17
Soda,	3·23	"	" "	0·82

From the oxygen ratio of this it appears that the phosphoric acid and lime exist in the proportion of $3CaO, PO_5$. The crucible after ignition showed indications that chlorid of iron had been volatilized.

Below this exterior crust the rock has a varied appearance; it is of a dark brown color, in places quite black, and varying in others to a lighter shade, in which portion are frequent cavities filled with minute crystals of gypsum, readily recognizable with a pocket lens. The darkest portion is the most solid, with a slightly vitreous lustre, and of a much greater density and hardness than any other portion of the guano; it has a sub-conchoidal fracture, sometimes splitting into thin fragments which are translucent; through some portions of it I have frequently observed thin irregular bands, $\frac{1}{32}$d to $\frac{1}{16}$th of an inch in width, which have the appearance of carbon.

This portion was selected for analysis with particular care, with the view to ascertain its exact composition; it was with difficulty reduced to the finest powder and treated with distilled water (in the cold) in a beaker glass, being frequently stirred for several days in order that the water should be in frequent contact with the particles; it was then collected on a weighed filter and washed with cold water until the filtrate showed no trace of sulphuric acid; the excess of filtrate was evaporated to dryness, and a thorough analysis made of it, the result of which is the following:—

(II.)

3·9922	grammes	0·3836	grams.	BaO, SO_3	gave	sulphuric acid	3·30
"	"	0·1761	"	CaO, CO_2	"	lime	2·48
"	"	0·0099	"	Ag	"	chlorine	0·08
"	"	0·0531	"	2MgO, PO_5	"	phosphoric acid	0 85
"	"	0·0089	"	Na Cl	"	soda	0·88

Per-centage	sulphuric acid,	3·30	Oxygen ratio,	1·97		
" "	phosphoric acid,	0·85	" "	0·54		
" "	lime,	2·48	" "	0·70		
" "	soda,	0·88	" "	0·22		
" "	chlorine,	0·08	" "			

There was in this analysis a loss of lime or magnesia, and also of the insoluble residue.

A selection was made from other specimens which resembled very nearly that above described; it was treated in the same manner as (II), but the results show a marked difference, there being a smaller per-centage of phosphate of lime dissolved from (II) than from (III), and a proportional amount of chlorid of sodium. To this fact I shall again refer.

The following is the result of the analysis:

(III.)

The residue before weighing was carefully dried at 100° C.

2·7271	grammes	left, residue of 2·3177 gram.					84·98
"	"	0·0095	grams.	Ag	gave	chlorine,	0·11
"	"	0·3603	"	BaO, SO_3	"	sulphuric acid,	4·91
"	"	0·2536	"	CaO, SO_3	"	lime,	3·84
"	"	0·0083	"	2MgO, PO_5	"	magnesia,	0·11
"	"	0·0600	"	2MgO, PO_5	"	phosphoric acid,	1·58
"	"	0·0201	"	Na Cl	"	soda,	0·40

Chlorine,	0·11	per cent.	Oxygen ratio,	
Sulphuric acid,	4·91	" "	" "	2·94
Phosphoric acid,	1·58	" "	" "	0·88
Lime,	3·84	" "	" "	1·09
Magnesia,	0·11	" "	" "	0·04
Soda,	0·40	" "	" "	0·10

From another portion of the rock the black portions were selected for analysis; the quantity of sulphate of lime is very inconstant. The results of the analysis were as follows:

(IV.)

0·9170	grams.	·0536	gram.	BaO, SO_3	gave	sulphuric acid,	2·01 p. c.
"	"	0·0510	"	CaO, CO_2	"	lime,	3·13 "
"	"	0·1532	"	Fe_2O_3	"	sesquioxyd of iron,	16·71 "
"	"	0·1123	"	Al_2O_3	"	alumina,	12·25 "
2·0741	"	lost by heating, 0·3254					15·69 "
"	"	insoluble residue, 0·1314					6·13 "

Owing to an accident to the platinum crucible just before weighing, the phosphoric acid was not determined.

Sulphuric acid,	2·01 per cent.	Oxygen ratio,	1·20
Lime,	3·13 " "	" "	0·89
Sesquioxyd of iron,	16·71 " "	" "	5·00
Alumina,	12·25 " "	" "	5·70

The specimens from which the material for the above analyses were selected, I received from Messrs. Richards and Miller, agents for the Philadelphia Guano Company; there is doubt as to their exact locality; in appearance they correspond exactly with that from Monk's Island, but the results of the analyses are very different from those obtained from the specimens from this island which I received from Dr. Luther.

That alumina is present as a phosphate, in the guano from Monk's Island, I have proved, by treating 3·4023 grammes of an average sample of the cargo of Schr. Trident from Monk's Island, with pure caustic potash in a silver dish, which was found to contain 1·32 per cent of alumina.

Specimens were given me from Monk's Island by Dr. Luther, the characteristic appearance of which has already been described.

1·5915 grammes were treated in a silver dish with potash, but not a trace of alumina could be detected; the residue dissolved in hydrochloric acid was found to contain lime, 39·08 per cent.

The guano rock from Monk's Island when finely powdered and treated with distilled water, gave an acid reaction with litmus paper.

(V.)

1·7076 grammes (organic matter and water not determined).

"	"	0·1993 gram.	BaO, SO_3	gave sulphuric acid,	4·00 p. c.
"	"	0·0780 "	$2MgO, PO_5$	" magnesia,	1·64 "
"	"	1·1999 "	CaO, CO_2	" lime,	39·34 "
"	"	1·1461 "	$2MgO, PO_5$	" phosphoric acid,	42·98 "

Sulphuric acid,	4·00 per cent.	Oxygen ratio,	2·39
Magnesia,	1·64 " "	" "	0·65
Lime,	39·34 " "	" "	11·10
Phosphoric acid,	42·98 " "	" "	24·09

For the oxygen of the sulphuric acid, 2·39, there are required 0·88 of the oxygen of the lime; and if to the remainder be added the oxygen of the magnesia, we have 10·95, which is to the oxygen of the phosphoric acid very nearly as 1 : 2.

(VI.)

2·8678 grammes treated with distilled water gave:

"	"	2·7076 grams.	residue,		94·41 p. c.
"	"	0·1287 "	BaO, SO_3	gave sulphuric acid,	1·49 "
"	"	0·0655 "	CaO, CO_2	" lime,	1·27 "
"	"	0·0363 "	$2MgO, PO_5$	" phosphoric acid,	0·81 "

2·8426 grammes treated with distilled water gave:

"	"	0·0076 grams.	Ag	gave	chlorine,	0·09 p. c.
"	"	0·0347 "	$2MgO, PO_5$	"	phosphoric acid,	0·78 "
"	"	0·1099 "	BaO, SO_3	"	sulphuric acid,	1·33 "

Lime,	1·27 per cent.	Oxygen ratio,	0·36
Phosphoric acid,	0·81 " "	" "	0·45
Sulphuric acid,	1·49 " "	" "	0·89

Guano rock has been brought from another group of islands called Centinella, consisting of peaks, which sometimes attain a height of 800 feet. The rock is described as consisting of two layers, the upper of which is a dark-brown compact rock, varying slightly from the lower layer. This so-called lower layer has certainly a surface exposed, as the specimen which I have examined, has been much weathered; the outer portion is partially reniform, and in places it shows a slight enamel, though not near as distinctly as the specimens from Monk's and El Roque islands. It has evidently been formed in layers, which when broken across show a slightly banded appearance not unlike that already described as characteristic of portions of the rock from Monk's Island; the color varies from a buff to an ochreous brown; it is hard, brittle, and much more readily pulverized than the Monk's Island guano rock. An opinion may seem premature, but I am inclined to the belief that this has once been in the same condition as the guano rock from Monk's Island, which has undergone changes from causes not yet fully studied; this seems probable from the fact that small quantities of phosphate of alumina have been found in the Monk's Island rock.

The whitest portion of the rock was selected for an analysis, which gave the following results:

(VII.)

1·5165 grams.	ignited gave	·3469 grams.				22·87 p. c.
" "	0·2000 grams.	insoluble matter,			silica,	13·18 "
" "	0·0474 "	BaO, SO_3	gave	sulphuric acid,		1·07 "
" "	0·6921 "	$2MgO, PO_5$	"	phosphoric acid,		29·23 "
" "	0·0720 "	CaO, CO_2	"	lime,		2·66 "
1·3048 "	0·2120 "	Al_2O_3	"	alumina,		16·24 "
" "	0·1628 "	Fe_2O_3	"	sesquiox. of iron,		12·41 "
" "	0·6438 "	$2MgO, PO_5$	"	phosphoric acid,		31·60 "
" "	0·0660 "	CaO, CO_2	"	lime,		2·83 "
" "	0·0057 "	$2Al_2O_3, 3PO_5$?	"	phosph.of alumina,		0·43 "

Water?	22·87 per cent.	Oxygen ratio,	21·54
Silica,	13·18 " "	" "	6·84
Sulphuric acid,	1·07 " "	" "	0·65
Phosphoric acid,	31·60 " "	" "	20·24
Lime,	2·66 " "	" "	0·75
Alumina,	16·24 " "	" "	7·59
Sesquioxyd of iron,	12·41 " "	" "	3·61

The 0·65 of oxygen of the sulphuric acid requires 0·22 of the oxygen of the lime; the remaining lime is most likely combined with carbonic acid, as nearly every specimen on treating with dilute acid gave a slight effervescence (the guano rock from the vertical cliff contained nearly one per cent), or possibly a remnant of the once phosphate of lime still exists. The alumina and phosphoric acid exist most likely in the form of wavellite, which has the formula $3Al_2O_3$, $2PO_5+12HO$. It is difficult in a rock which is in progress of decomposition to obtain other than approximate formulæ.

This island of Centinella is now inhabited by immense numbers of water-fowl, many of which roost on the cliffs; some of these roosts have been long occupied, and judging from the signs on the rocks beneath, have been much resorted to. Mr. Richards of Philadelphia, who visited the islands a short time since, broke off a portion of the concretion which covers the cliffs beneath a bird roost of this description; the organic properties had been mostly removed by causes which had converted the inorganic constituents into a guano rock, which in composition is not unlike that from Monk's Island and El Roque. Mr. Richards mentioned that when first obtained it had quite a strong odor, which has now almost disappeared; it is very hard and was difficult to powder.

The analysis of the concretion is as follows:

(VIII.)

2·0904	grams.	on ignition lost	0·2361	gram.		11·29 p.c.
2·2904	"	0·0248 grams.	Al_2O_3	gave	alumina,	1·08 "
·8470	"	0·066 "	BaO, SO_3	"	sulphuric acid,	2·67 "
"	"	0·4707 "	CaO, CO_2	"	lime,	31·18 "
"	"	0·0406 "	$2MgO, PO_5$	"	magnesia,	1·74 "
"	"	0·0143 "	Fe_2O_3 & Al_2O_3	"	iron and alumina,	1·69 "
"	"	0·0506 "	insoluble,	"	silica,	5·97 "
1·8570	"	1·0153 "	CaO, CO_2	"	lime,	30·68 "
"	"	0·0926 "	$2MgO, PO_5$	"	magnesia,	1·79 "
"	"	0·0346 "	Fe_2O_3 Al_2O_3	"	alumina and iron,	1·86 "
"	"	1·2520 "	$2MgO, PO_5$	"	phosphoric acid,	41·89 "
1·2142	"	contained 0·0089 grams.	CO_2	"	carbonic acid,	0·73 "

Alumina and iron,	1·86 per cent.	Oxygen ratio,	0·86
Sulphuric acid,	2·67 " "	" "	1·59
Carbonic acid,	0·73 " "	" "	0·54
Lime,	31·18 " "	" "	8·86
Magnesia,	1·74 " "	" "	0·69
Phosphoric acid,	41·89 " "	" "	23·25

1·59 oxygen of sulphuric acid require 0·53 of oxygen of the lime; and 0·53 of oxygen of the carbonic acid require 0·27 oxygen of the lime; but if there is added to this remainder the oxygen

of the magnesia, there remains 8·75 oxygen of lime, which is to the oxygen of phosphoric acid 23·25, about in the ratio of 1 : 2, particularly as the oxygen of the alumina requires oxygen of the phosphoric acid, to form a salt with a formula most probably corresponding to that of wavellite as before mentioned.

Mr. Richards brought with him also a specimen of the recent alluvial guano or bird excrement, as it may be justly termed; he obtained it from a little nook in the rocks, where it was protected from the intense dry heat of the sun and from the action of water. Mixed through it were several birds feathers. As may readily be imagined, it had some odor, though not excessively strong.

7·4921 grams. were ignited in a platinum crucible, and gave a very strong and disagreeable odor like burning hair; it was moistened with carbonate of ammonia and again gently heated, and gave a loss of 4·0032 grams. = 53·83 per cent.

(IX.)

2·1975 grams.	of the ash showed a trace of alumina.				
" "	0·2746 grams.	BaO, SO_3	gave sulphuric acid,		4·29
2·236 "	1·5150 "	CaO, CO_2	" lime,		38·02
" "	0·0913 "	sand	"		4·83
4·0704 "	ignited gave a loss 1·9171 gram.				47·10
1·9997 "	ash				
" "	1·3858 grams.	CaO, CO_2	gave lime,		38·89
" "	0·2206 "	BaO, SO_3	" sulphuric acid,		3·79
" "	0·2100 "	$2MgO, PO_5$	" magnesia,		3·77
" "	1·3178 "	$2MgO, PO_5$	" phosphoric acid,		42·21
" "	0·0225 "	sand	"		3·25
" "	0·0164 "	Ag	" chlorine,		0·26
3·9652 "	loss by ignition 1·9282 gram.				48·62
·9857 "	0·6892 grams.	$CaO. CO_2$	gave lime,		39·12
·9794 "	0·0085 "	CO_2	" carbonic acid,		0·86
" "	0·1250 "	BaO, SO_3	" sulphuric,		4·28

Lime,	38·89 per cent.	Oxygen ratio,	11·05
Phosphoric acid,	42·21 " "	" "	23·65
Sulphuric acid,	4·29 " "	" "	2·57
Magnesia,	3·77 " "	" "	1·50

2·57 oxygen in sulphuric acid require 0·85 oxygen in lime; there remains 10·19 oxygen of lime, which, if added to the oxygen of the magnesia makes 11·69, which stands with the oxygen of the phosphoric acid 23·65, near the ratio $2CaO, PO_5$.

A guano rock has recently been brought from a group of islands called El Roque, in the Caribbean Sea. In composition it resembles very closely that brought from Monk's Island; the specimens that I have analyzed, contain however, a much larger quantity of sulphuric acid than has been found in the latter rock.

The appearance of the body of the two rocks is also much alike, but in the specimens which I have seen from El Roque the exterior crust is very different; it is rarely more than a slight coating; in some places it has a slight appearance of the enamel, when examined with a pocket lens; the surface is very irregular, often containing cavities which are lined with the same white coating. It was impossible to obtain sufficient of this for analysis: the analysis of the black portion of the rock was as follows:

(X.)

1·8636 grms.	loss by ign.	0·1904 grms.	water & organic matter	10·22 p. c.
1·4609 "	0·3274 grms.	BaO, SO_3	gave sulphuric acid,	7·70 "
" "	1·0066 "	CaO, CO_2	" lime,	38·67 "
" "	0·1118 "	$2MgO, PO_5$	" magnesia,	2·75 "
" "	0·0116 "	insoluble		0·78 "
" "	0·0058 "	Fe_2O_3 & Al_2O_3	" iron and alumina,	0·40 "
1·1680 "	0·7936 "	CaO, CO_2	" lime,	38·12 "
" "	0·0879 "	$2MgO, PO_5$	" magnesia,	2·70 "
" "	0·7383 "	$2MgO, PO_5$	" phosphoric acid,	40·49 "

Organic matter and water,	10·22 per cent.				
Sulphuric acid,	7·70 " "	Oxygen ratio,	4·61		
Lime,	38·67 " "	" "	10·09		
Magnesia,	2·75 " "	" "	1·09		
Phosphoric acid,	40·49 " "	" "	25·93		
Alumina and sesquioxyd of iron,	0·40				
Insoluble,	0·78				

4·61 oxygen in sulphuric acid require 1·54 oxygen in lime; there remains therefore 8·55 oxygen in lime which stands with the oxygen of phosphoric acid 25·93, in the ratio 1 : 3, showing that the phosphate in this specimen consists principally of $3CaO, PO_5$.

A specimen containing no organic matter was examined from Testigoe Island, but the rock was very much disintegrated; it was very porous, and evidently had been acted upon by some causes which were gradually removing all its components except the silica. In appearance it was largely a sandstone, as the analysis showed. The most compact portion of the specimen was selected, which was readily pulverized; the results of the analysis differ from all the other specimens. The following are the results:

(XI.)

1·2910 grams.	insoluble silica	0·6722 grams.			52·07 p. c.
" "	0·0085	CaO, CO_2	gave	lime,	0·37 "
" "	0·0206	$2MgO$	"	magnesia,	0·57 "
0·8806 "	0·1073	loss by ignition	"	water,	12·17 "
0·8806 "	insoluble	0·4600 grams.	"	silica,	52·27 "
				sulphuric acid,	*trace.*

0·8806 grams. 0·1158 Al_2O_3 gave alumina, 13·03 p. c.
" " $2Fe_2O_3$, $3PO_5$ } 0·0318 " phosphate of iron, 3·61 "
" " $2MgO, PO_5$ 0·2394 " phosphoric acid, 17·41 "

Silica,	52·07 per cent.				
Lime,	0·37 " "				
Magnesia,	0·57 " "				
Water,	12·17 " "	Oxygen ratio,	10·81		
Sulphuric acid,	*trace*				
Alumina,	13·03 " "	"	"	6·12	
Phosphate of iron,	3·61 " "				
Phosphoric acid,	17·41 " "	"	"	9·81	

The alumina and phosphoric acid seem in this to be in the form of wavellite.

The guano rock from the various groups of islands has very varying composition, as has been seen from the foregoing investigations. It is found in layers, and the surface sometimes covered with an alluvial deposit; these layers are in places highly inclined, showing that since their deposition their original position has been altered. This same phenomenon is described as occurring at the Chincha islands in the Peruvian guano where it is found in layers two or three yards in thickness.

Prof. C. U. Shepard has, with his characteristic energy, extended his mineralogical species to various portions of this rock. He designates the so-called species generally as Pyroguanite minerals, and describes them as entirely destitute of ammonia;* but examinations made of an average sample of a cargo from Monk's Island show one-half per cent of nitrogen. Every specimen which I have examined, has on ignition given very marked evidence of burning organic matter. How this can be retained in a rock that has been subjected to the agency of heated trap is as difficult to understand, as that minerals existing with, and forming a part of, its mass, as Prof. Shepard describes, contain water in their composition. Moreover, how can a rock subjected to the agency of heated trap have as its principal basis a salt with the formula 2CaO, HO, PO_5, which is the formula ascribed to it by Drs. Piggot and Beckell, of Baltimore, and which seems to be the proper composition of some portions, as shown by the analysis of Monk's Island rock (V),—though in the analysis of the specimen from El Roque (X) there is obtained the formula 3CaO, PO_5.

As I have already mentioned, this guano rock from *Los Monges* has been called a native super-phosphate of lime, but no satisfactory proofs are given as to its meriting such a name; phosphoric acid being found in solution after the guano is treated

* Am. J. Sci. [2], xxii, 96.

with water is no proof that it exists in a free state. Phosphate of lime, when recently precipitated, is soluble to a slight extent in pure water (R. Phillips, Ann. Phil. 22, 188). Berzelius long since discovered phosphates of lime and alumina in the water and deposits of hot springs at Carlsbad.* That phosphates are insoluble and must be rendered free before becoming efficacious as fertilizers is an erroneous though a very prevalent opinion. According to Bischof† phosphate of lime must be regarded as present in all water running into the sea; it has already been detected in the waters of the Dee and of the Don, and it will most likely be found in the waters of all rivers. Phosphate of lime and magnesia have also been found in the waters of an artesian well at Wildegg, in the Canton Argan (Switzerland). Phosphate of lime has been shown to be present in sea water by Clemm‡ and by Forchhammer.§ According to Berzelius it is the *di*-phosphate which is found in the mineral waters,‖ which is readily soluble in water saturated with carbonic acid. The basic phosphate of lime is also readily soluble in water containing carbonic acid; Bischof gives a very interesting table of the degrees of solubility of the various basic phosphates of lime in water saturated with carbonic acid gas.¶

It is not only in carbonic acid waters that phosphate of lime is soluble; basic phosphate of lime dissolves in 3·150 parts of water, containing one-twelfth by weight of chlorid of sodium. The presence of chlorid of ammonium increases the solubility still more.¶

It is probable, therefore, that the solubility of the phosphate of lime guano rock from Los Monges is owing to the presence of the chlorid of sodium existing in it. By reference to the analyses (II and III), it will be seen that the phosphate of lime dissolved is in proportion to the chlorid of sodium in the specimens. This will, however, require more detailed examination.

Though the rock from Centinella, containing so large a percentage of phosphoric acid combined with iron and alumina, may seem at first worthless as a fertilizer, no positive opinion should be formed or expressed without a very careful investigation of the subject, which I believe has never yet been made. It is true that phosphate of alumina is one of the most sparingly soluble substances known; still it is soluble in water saturated with carbonic acid, according to Bischof in about 6,828,000 parts, while in the water of the Carlsbad springs about double this quantity is held in solution, viz. $\frac{1}{3\,1\,3\,3\,3\,3\,3}$.**

* Gilbert's Annalen, lxxiv, 136.
† Chem. and Phys. Geology, vol. 2, p. 27 (Engl. edit.).
‡ Journ. für prakt. Chemie, xxxiv, 185. § Berzelius, Jahresbericht, xxvi, 393.
‖ Gmelin, vol. iii, p. 195. ¶ Chem. and Phys. Geology, vol. ii, p. 28.
** Chem. and Phys. Geol., vol. ii, p. 34.

Though the phosphate of lime is applied to soils, and, as such, taken up by plants, there is no proof that it remains in that form until the plants have need of it; it enters into new combinations, some of which may be quite as insoluble as this Centinella rock. The phosphate of lime dissolved by the carbonated waters always found more or less in soils,* is decomposed by alkaline carbonates; the lime would therefore be converted into a carbonate, and a phosphate of the alkali would be formed.† Boussingault and Levy, (Journ. des Debats, Dec. 5, 1852,) found that the air in the interstices of arable soils contained as much as 22 to 23 times as much carbonic acid as the atmosphere, and when the soil has been recently moistened, 245 times as much. Phosphate of lime lying in such a soil would be dissolved in a comparatively short space of time.

Carbonate of iron is present more or less in every soil, and consequently, if in a soil the carbonate of iron and phosphate of lime exist, both held in solution by a carbonate of the alkalies, a mutual decomposition may take place,‡ consequently we may have vivianite formed in the soil: instances are frequent of vivianite in fossils of the greensand of New Jersey,§ but geological ages are not required to produce these changes. M. Jerome Nicklès has recognized its presence in human bones (Am. Jour. of Sci., vol. xxi, p. 402); he found in a cemetery at Eumont, a village in the department of LaMeurthe, the earth of which was very ferruginous, two arm bones of a female, a cubitus and a radius, having a deep bluish green color. On breaking, the alteration was found to be complete, and a qualitative chemical examination proved it to be phosphate of iron. It is to be regretted that a quantitative analysis was not made, to have determined whether all the bone phosphate had been decomposed and the transformation into phosphate of iron complete. M. Nicklès, on examining the medullary cavity with a lens, found among the sinuosities left by the hardened marrow brilliant

* Researches have been made by Lassaigne, Journ. Chim. Med., [3], iv, 354; and Ann. de Chim. et de Phys., [3], xxv, 346, show that phosphate of lime is conveyed into the plant organism by water saturated with carbonic acid. Dumas (Comptes Rendus, xxiii, 1018) holds the same opinion.

† Bischof, Chem. and Phys. Geology, vol. i, p. 13, No. 19. Phosphate of lime dissolved in carbonated water forms carbonate of lime, which is precipitated, and alkaline phosphate which remains in solution.

‡ Phosphate of lime dissolved in carbonated waters and proto-carbonate of iron form a proto-phosphate of iron, which is precipitated, and bi-carbonate of lime which remains in solution. (Bischof, vol. i, p. 13, No. 20)

§ In the greensand of New Jersey, the decomposition is not owing probably to the carbonate of iron, but to the sulphate resulting from oxydation of the iron pyrites. (Bischof, vol. i, p. 14, No. 21.) Phosphate of iron and proto-sulphate of iron form sulphate of lime and proto-phosphate of iron. Similar changes probably result in this guano rock, as in many specimens we find crystals of gypsum recognizable with a pocket-lens.

points which were distinctly crystals of vivianite. The bones were in a perfect state of preservation, and afforded, when treated with hydrochloric acid, a skeleton of gelatine, proving that gelatine does not resist the absorption of the ferruginous compound.

Various theories have been formed and published as to the origin of the rock guano; these are most likely premature, as the accounts as to its occurrence are founded on reports of those not accustomed to noting geological phenomena.

The islands of the Caribbean Sea are very varied. Some are quite low and covered with sand composed of fragments of shells, madrepore and corals, which can readily be distinguished with a pocket lens. These sands are resorted to by myriads of waterfowls for laying their eggs. One of the captains who visited there mentions that it is necessary to make one's way through them with a stick. Other islands attain heights of 800 feet; it seems improbable that such heights could be created by accretions of guano and sand, when the islands were subject to a continued action of the waves of the ocean; and from the inclined position of the guano layers it might be inferred that an uplift had taken place since the layers were formed. But on this point more direct evidence is needed.

It is most probable that the guano rock from some of the islands has been changed in its composition by reactions of the salts contained in sea water; but before such reactions can be fully explained, accurate analyses must be made of this sea water.

It is a remarkable fact, that the composition of the ash from the recent guano from the heights of the Centinella rock composed of phosphates of alumina and iron, should have a composition so very near that of the guano rock from the Los Monges and El Roque islands. The frequent occurrence of alumina and iron is to be remarked in the guano rocks.

Note.—I have just been informed by Dr. Luther, that from analyses lately made in Baltimore of a cargo of rock guano that has lately arrived from the island of Testigoes, there has been found from forty to forty-five per cent of phosphoric acid.

ART. XV.—*On the Interaction of Natural Forces;** by H. HELMHOLTZ, Professor of Physiology in the University of Königsberg.†

A NEW conquest of very general interest has been recently made by natural philosophy. In the following pages I will endeavor to give a notion of the nature of this conquest. It has reference to a new and universal natural law, which rules the action of natural forces in their mutual relations towards each other, and is as influential on our theoretic views of natural processes as it is important in their technical applications.

Among the practical arts which owe their progress to the development of the natural sciences, from the conclusion of the middle ages downwards, practical mechanics, aided by the mathematical science which bears the same name, was one of the most prominent. The character of the art was, at the time referred to, naturally very different from its present one. Surprised and stimulated by its own success, it thought no problem beyond its power, and immediately attacked some of the most difficult and complicated. Thus it was attempted to build automaton figures which should perform the functions of men and animals. The wonder of the last century was Vaucanson's duck, which fed and digested its food; the flute player of the same artist, which moved all its fingers correctly; the writing boy of the older, and the pianoforte player of the younger Droz; which latter, when performing, followed its hands with its eyes, and at the conclusion of the piece bowed courteously to the audience. That men like those mentioned, whose talent might bear comparison with the most inventive heads of the present age, should spend so much time in the construction of these figures which we at present regard as the merest trifles, would be incomprehensible, if they had not hoped in solemn earnest to solve a great problem. The writing boy of the elder Droz was publicly exhibited in Germany some years ago. Its wheelwork is so complicated that no ordinary head would be sufficient to decipher its manner of action. When, however, we are informed that

* A popular scientific discourse, delivered the 7th of February, 1854. Cited from Phil. Mag., Fourth Series, volume 11, page 489, where it is accompanied by the following note by the translator, John Tyndall, Ph.D., F.R.S.—"The following article is a translation of a popular lecture, but it will, I doubt not, be studied with interest by many of the readers of this Journal. I once had thoughts of presenting the lecture in a condensed form, omitting allusions, which though proper and necessary in a spoken discourse, might not appear so in a strictly scientific article. On reflection, however, I think it better to let the accomplished author state, in his own fashion, the important question which he has contributed so much to expand and elucidate."

† Now of the University of Bonn.

this boy and its constructor, being suspected of the black art, lay for a time in the Spanish Inquisition, and with difficulty obtained their freedom, we may infer that in those days even such a toy appeared great enough to excite doubts as to its natural origin. And though these artists may not have hoped to breathe into the creature of their ingenuity a soul gifted with moral completeness, still there were many who would be willing to dispense with the moral qualities of their servants, if at the same time their immoral qualities could also be got rid of; and accept, instead of the mutability of flesh and bones, services which should combine the regularity of a machine with the durability of brass and steel. The object, therefore, which the inventive genius of the past century placed before it with the fullest earnestness, and not as a piece of amusement merely, was boldly chosen, and was followed up with an expenditure of sagacity which has contributed not a little to enrich the mechanical experience which a later time knew how to take advantage of. We no longer seek to build machines which shall fulfil the thousand services required of *one* man, but desire, on the contrary, that a machine shall perform *one* service, yet shall occupy in doing it the place of a thousand men.

From these efforts to imitate living creatures, another idea, also by a misunderstanding, seems to have developed itself, which, as it were, formed the new philosopher's stone of the seventeenth and eighteenth centuries. It was now the endeavor to construct a perpetual motion. Under this term was understood a machine, which, without being wound up, without consuming in the working of it falling water, wind, or any other natural force, should still continue in motion, the motive power being perpetually supplied by the machine itself. Beasts and human beings seemed to correspond to the idea of such an apparatus, for they moved themselves energetically and incessantly as long as they lived, and were never wound up; nobody set them in motion. A connexion between the taking-in of nourishment and the development of force did not make itself apparent. The nourishment seemed only necessary to grease, as it were, the wheelwork of the animal machine, to replace what was used up, and to renew the old. The development of force out of itself seemed to be the essential peculiarity, the real quintessence of organic life. If, therefore, men were to be constructed, a perpetual motion must first be found.

Another hope also seemed to take up incidentally the second place, which in our wiser age would certainly have claimed the first rank in the thoughts of men. The perpetual motion was to produce work inexhaustibly without corresponding consumption, that is to say, out of nothing. Work, however, is money. Here, therefore, the great practical problem which the cunning

heads of all centuries have followed in the most diverse ways, namely, to fabricate money out of nothing, invited solution. The similarity with the philosopher's stone sought by the ancient chemists was complete. That also was thought to contain the quintessence of organic life, and to be capable of producing gold.

The spur which drove men to inquiry was sharp, and the talent of some of the seekers must not be estimated as small. The nature of the problem was quite calculated to entice poring brains, to lead them round a circle for years, deceiving ever with new expectations which vanished upon nearer approach, and finally reducing these dupes of hope to open insanity. The phantom could not be grasped. It would be impossible to give a history of these efforts, as the clearer heads, among whom the elder Droz must be ranked, convinced themselves of the futility of their experiments, and were naturally not inclined to speak much about them. Bewildered intellects, however, proclaimed often enough that they had discovered the grand secret; and as the incorrectness of their proceedings was always speedily manifest, the matter fell into bad repute, and the opinion strengthened itself more and more, that the problem was not capable of solution; one difficulty after another was brought under the dominion of mathematical mechanics, and finally a point was reached where it could be proved, that at least by the use of pure mechanical forces no perpetual motion could be generated.

We have here arrived at the idea of the driving force or power of a machine, and shall have much to do with it in future. I must therefore give an explanation of it. The idea of work is evidently transferred to machines by comparing their arrangements with those of men and animals, to replace which they were applied. We still reckon the work of steam-engines according to horse power. The value of manual labor is determined partly by the force which is expended in it (a strong laborer is valued more highly than a weak one), partly, however, by the skill which is brought into action. A machine, on the contrary, which executes work skilfully, can always be multiplied to any extent; hence its skill has not the high value of human skill in domains where the latter cannot be supplied by machines. Thus the idea of the quantity of work in the case of machines has been limited to the consideration of the expenditure of force; this was the more important, as indeed most machines are constructed for the express purpose of exceeding, by the magnitude of their effects, the powers of men and animals. Hence, in a mechanical sense, the idea of work is become identical with that of the expenditure of force, and in this way I will apply it in the following pages.

How, then, can we measure this expenditure, and compare it in the case of different machines?

I must here conduct you a portion of the way—as short a portion as possible—over the uninviting field of mathematico-mechanical ideas, in order to bring you to a point of view from which a more rewarding prospect will open. And though the example which I shall here choose, namely, that of a water-mill with iron hammer, appears to be tolerably romantic, still, alas, I must leave the dark forest valley, the spark-emitting anvil, and the black Cyclops wholly out of sight, and beg a moment's attention to the less poetic side of the question, namely, the machinery. This is driven by a water-wheel, which in its turn is set in motion by the falling water. The axle of the water-wheel has at certain places small projections, thumbs, which, during the rotation, lift the heavy hammer and permit it to fall again. The falling hammer belabors the mass of metal, which is introduced beneath it. The work therefore done by the machine consists, in this case, in the lifting of the hammer, to do which the gravity of the latter must be overcome. The expenditure of force will in the first place, other circumstances being equal, be proportional to the weight of the hammer; it will, for example, be double when the weight of the hammer is doubled. But the action of the hammer depends not upon its weight alone, but also upon the height from which it falls. If it falls through two feet, it will produce a greater effect than if it falls through only one foot. It is, however, clear that if the machine, with a certain expenditure of force, lifts the hammer a foot in height, the same amount of force must be expended to raise it a second foot in height. The work is therefore not only doubled when the weight of the hammer is increased twofold, but also when the space through which it falls is doubled. From this it is easy to see that the work must be measured by the product of the weight into the space through which it ascends. And in this way, indeed, do we measure in mechanics. The unit of work is a foot-pound, that is, a pound weight raised to the height of one foot.

While the work in this case consists in the raising of the heavy hammer-head, the driving force which sets the latter in motion is generated by falling water. It is not necessary that the water should fall vertically, it can also flow in a moderately inclined bed; but it must always, where it has water-mills to set in motion, move from a higher to a lower position. Experiment and theory coincide in teaching, that when a hammer of a hundred weight is to be raised one foot, to accomplish this at least a hundred weight of water must fall through the space of one foot; or what is equivalent to this, two hundred weight must fall half a foot, or four hundred weight a quarter of a foot, &c. In short, if we multiply the weight of the falling water by

the height through which it falls, and regard, as before, the product as the measure of the work, then the work performed by the machine in raising the hammer, can, in the most favorable case, be only equal to the number of foot-pounds of water which have fallen in the same time. In practice, indeed, this ratio is by no means attained: a great portion of the work of the falling water escapes unused, inasmuch as part of the force is willingly sacrificed for the sake of obtaining greater speed.

I will further remark, that this relation remains unchanged whether the hammer is driven immediately by the axle of the wheel, or whether—by the intervention of wheelwork, endless screws, pulleys, ropes—the motion is transferred to the hammer. We may, indeed, by such arrangements succeed in raising a hammer of ten hundred weight, when by the first simple arrangement the elevation of a hammer one hundred weight might alone be possible; but either this heavier hammer is raised to only one-tenth of the height, or tenfold the time is required to raise it to the same height; so that, however we may alter, by the interposition of machinery, the intensity of the acting force, still in a certain time, during which the mill-stream furnishes us with a definite quantity of water, a certain definite quantity of work, and no more, can be performed.

Our machinery, therefore, has in the first place done nothing more than make use of the gravity of the falling water in order to overpower the gravity of the hammer, and to raise the latter. When it has lifted the hammer to the necessary height, it again liberates it, and the hammer falls upon the metal mass which is pushed beneath it. But why does the falling hammer here exercise a greater force than when it is permitted simply to press with its own weight on the mass of metal? Why is its power greater as the height from which it falls is increased? We find, in fact, that the work performed by the hammer is determined by its velocity. In other cases, also, the velocity of moving masses is a means of producing great effects. I only remind you of the destructive effects of musket-bullets, which in a state of rest are the most harmless things in the world. I remind you of the windmill, which derives its force from the moving air. It may appear surprising that motion, which we are accustomed to regard as a non-essential and transitory endowment of bodies, can produce such great effects. But the fact is, that motion appears to us under ordinary circumstances transitory, because the movement of all terrestrial bodies is resisted perpetually by other forces, friction, resistance of the air, &c., so that the motion is incessantly weakened and finally neutralized. A body, however, which is opposed by no resisting force, when once set in motion, moves onward eternally with undiminished velocity. Thus we know that the planetary bodies have moved without

change through space for thousands of years. Only by resisting forces can motion be diminished or destroyed. A moving body, such as the hammer or the musket-ball, when it strikes against another, presses the latter together, or penetrates it, until the sum of the resisting forces which the body struck presents to its pressure, or to the separation of its particles, is sufficiently great to destroy the motion of the hammer or of the bullet. The motion of a mass regarded as taking the place of working force is called the living force (*vis viva*) of the mass. The word "living" has of course here no reference whatever to living beings, but is intended to represent solely the force of the motion as distinguished from the state of unchanged rest—from the gravity of a motionless body, for example, which produces an incessant pressure against the surface which supports it, but does not produce any motion.

In the case before us, therefore, we had first power in the form of a falling mass of water, then in the form of a lifted hammer, and thirdly in the form of the living force of the falling hammer. We should transform the third form into the second, if we, for example, permitted the hammer to fall upon a highly elastic steel beam strong enough to resist the shock. The hammer would rebound, and in the most favorable case would reach a height equal to that from which it fell, but would never rise higher. In this way its mass would ascend; and at the moment when its highest point has been attained it would represent the same number of raised foot-pounds as before it fell, never a greater number; that is to say, living force can generate the same amount of work as that expended in its production. It is therefore equivalent to this quantity of work.

Our clocks are driven by means of sinking weights, and our watches by means of the tension of springs. A weight which lies on the ground, an elastic spring which is without tension, can produce no effects: to obtain such we must first raise the weight or impart tension to the spring, which is accomplished when we wind up our clocks and watches. The man who winds the clock or watch communicates to the weight or to the spring a certain amount of power, and exactly so much as is thus communicated is gradually given out again during the following twenty-four hours, the original force being thus slowly consumed to overcome the friction of the wheels and the resistance which the pendulum encounters from the air. The wheelwork of the clock therefore exhibits no working force which was not previously communicated to it, but simply distributes the force given to it uniformly over a longer time.

Into the chamber of an air-gun we squeeze, by means of a condensing air-pump, a great quantity of air. When we afterwards open the cock of a gun and admit the compressed air into

the barrel, the ball is driven out of the latter with a force similar to that exerted by ignited powder. Now we may determine the work consumed in the pumping-in of the air, and the living force which, upon firing, is communicated to the ball, but we shall never find the latter greater than the former. The compressed air has generated no working force, but simply gives to the bullet that which has been previously communicated to it. And while we have pumped for perhaps a quarter of an hour to charge the gun, the force is expended in a few seconds when the bullet is discharged; but because the action is compressed into so short a time, a much greater velocity is imparted to the ball than would be possible to communicate to it by the unaided effort of the arm in throwing it.

From these examples you observe, and the mathematical theory has corroborated this for all purely mechanical, that is to say, for moving forces, that all our machinery and apparatus generate no force, but simply yield up the power communicated to them by natural forces,—falling water, moving wind, or by the muscles of men and animals. After this law had been established by the great mathematicians of the last century, a perpetual motion, which should only make use of pure mechanical forces, such as gravity, elasticity, pressure of liquids and gases, could only be sought after by bewildered and ill-instructed people. But there are still other natural forces which are not reckoned among the purely moving forces,—heat, electricity, magnetism, light, chemical forces, all of which nevertheless stand in manifold relation to mechanical processes. There is hardly a natural process to be found which is not accompanied by mechanical actions, or from which mechanical work may not be derived. Here the question of a perpetual motion remained open; the decision of this question marks the progress of modern physics, regarding which I promised to address you.

In the case of the air-gun, the work to be accomplished in the propulsion of the ball was given by the arm of the man who pumped in the air. In ordinary firearms, the condensed mass of air which propels the bullet is obtained in a totally different manner, namely, by the combustion of the powder. Gunpowder is transformed by combustion for the most part into gaseous products, which endeavor to occupy a much larger space than that previously taken up by the volume of the powder. Thus you see, that, by the use of gunpowder, the work which the human arm must accomplish in the case of the air-gun is spared.

In the mightiest of our machines, the steam-engine, it is a strongly compressed aëriform body, water vapor, which, by its effort to expand, sets the machine in motion. Here also we do not condense the steam by means of an external mechanical force, but by communicating heat to a mass of water in a closed

boiler, we change this water into steam, which, in consequence of the limits of the space, is developed under strong pressure. In this case, therefore, it is the heat communicated which generates the mechanical force. The heat thus necessary for the machine we might obtain in many ways: the ordinary method is to procure it from the combustion of coal.

Combustion is a chemical process. A particular constituent of our atmosphere, oxygen, possesses a strong force of attraction, or, as it is named in chemistry, a strong affinity for the constituents of the combustible body, which affinity, however, in most cases can only exert itself at high temperatures. As soon as a portion of the combustible body, for example the coal, is sufficiently heated, the carbon unites itself with great violence to the oxygen of the atmosphere and forms a peculiar gas, carbonic acid, the same which we see foaming from beer and champagne. By this combination, light and heat are generated: heat is generally developed by any combination of two bodies of strong affinity for each other; and when the heat is intense enough, light appears. Hence in the steam-engine it is chemical processes and chemical forces which produce the astonishing work of these machines. In like manner the combustion of gunpowder is a chemical process, which in the barrel of the gun communicates living force to the bullet.

While now the steam-engine develops for us mechanical work out of heat, we can conversely generate heat by mechanical forces. A skillful blacksmith can render an iron wedge red-hot by hammering. The axles of our carriages must be protected by careful greasing from ignition through friction. And lately this property has been applied on a large scale. In some factories, where a surplus of water-power is at hand, this surplus is applied to cause a strong iron plate to rotate swiftly upon another, so that they become strongly heated by the friction. The heat so obtained warms the room, and thus a stove without fuel is provided. Now could not the heat generated by the plates be applied to a small steam-engine, which in its turn should be able to keep the rubbing plates in motion? The perpetual motion would thus be at length found. This question might be asked, and could not be decided by the older mathematico-mechanical investigations. I will remark beforehand, that the general law which I will lay before you answers the question in the negative.

By a similar plan, however, a speculative American set some time ago the industrial world of Europe in excitement. The magneto-electric machines often made use of in the case of rheumatic disorders are well known to the public. By imparting a swift rotation to the magnet of such a machine we obtain powerful currents of electricity. If those be conducted through wa-

ter, the latter will be reduced into its two components, oxygen and hydrogen. By the combustion of hydrogen, water is again generated. If this combustion takes place, not in atmospheric air, of which oxygen only constitutes a fifth part, but in pure oxygen, and if a bit of chalk be placed in the flame, the chalk will be raised to a white heat, and give us the sun-like Drummond's light. At the same time the flame develops a considerable quantity of heat. Our American proposed to utilize in this way the gases obtained from electrolytic decomposition, and asserted, that by the combustion a sufficient amount of heat was generated to keep a small steam-engine in action, which again drove his magneto-electric machine, decomposed the water, and thus continually prepared its own fuel. This would certainly have been the most splendid of all discoveries; a perpetual motion which, besides the force that kept it going, generated light like the sun, and warmed all around it. The matter was by no means badly cogitated. Each practical step in the affair was known to be possible; but those who at that time were acquainted with the physical investigations which bear upon this subject, could have affirmed, on first hearing the report, that the matter was to be numbered among the numerous stories of the fable-rich America; and indeed a fable it remained.

It is not necessary to multiply examples further. You will infer from those given, in what immediate connexion heat, electricity, magnetism, light, and chemical affinity, stand with mechanical forces.

Starting from each of these different manifestations of natural forces, we can set every other in motion, for the most part not in one way merely, but in many ways. It is here as with the weaver's web,—

> Where a step stirs a thousand threads,
> The shuttles shoot from side to side,
> The fibres flow unseen,
> And one shock strikes a thousand combinations.*

Now it is clear that if by any means we could succeed, through mechanical forces, as the above American professed to have done, to excite chemical, electrical, or other natural processes, which, by any circuit whatever, and without altering permanently the active masses in the machine, could produce mechanical force in greater quantity than that at first applied, a portion of the work thus gained might be made use of to keep the machine in motion, while the rest of the work might be applied to any other purpose whatever. The problem was to find, in the complicated

* "Wo ein Tritt tausend Fäden regt,
Die Schifflein herüber hinüber schiessen,
Die Fäden ungesehen fliessen,
Ein Schlag tausend Verbindungen schlägt."

net of reciprocal actions, a track through chemical, electrical, magnetical, and thermic processes, back to mechanical actions, which might be followed with a final gain of mechanical work: thus would the perpetual motion be found.

But, warned by the futility of former experiments, the public had become wiser. On the whole, people did not seek much after combinations which promised to furnish a perpetual motion, but the question was inverted. It was no more asked, how can I make use of the known and unknown relations of natural forces so as to construct a perpetual motion? but it was asked, if a perpetual motion be impossible, what are the relations which must subsist between natural forces? Everything was gained by this inversion of the question. The relations of natural forces rendered necessary by the above assumption, might be easily and completely stated. It was found that all known relations of forces harmonize with the consequences of that assumption, and a series of unknown relations were discovered at the same time, the correctness of which remained to be proved. If a single one of them could be proved false, then a perpetual motion would be possible.

The first who endeavored to travel this way was a Frenchman named Carnot, in the year 1824. In spite of a too limited conception of his subject, and an incorrect view as to the nature of heat, which led him to some erroneous conclusions, his experiment was not quite unsuccessful. He discovered a law which now bears his name, and to which I will return further on.

His labors remained for a long time without notice, and it was not till eighteen years afterwards, that is, in 1842, that different investigators in different countries, and independent of Carnot, laid hold of the same thought. The first who saw truly the general law here referred to, and expressed it correctly, was a German physician, J. R. Mayer of Heilbronn, in the year 1842. A little later, in 1843, a Dane named Colding, presented a memoir to the Academy of Copenhagen, in which the same law found utterance, and some experiments were described for its further corroboration. In England, Joule began about the same time to make experiments having reference to the same subject. We often find, in the case of questions to the solution of which the development of science points, that several heads, quite independent of each other, generate exactly the same series of reflections.*

* The following extract is taken from a lecture by Mr. Grove, delivered at the London Institution on the 19th of January, 1842:—

"Light, heat, electricity, magnetism, motion, and chemical affinity, are all convertible material affections; assuming any one as a cause, one of the others will be the effect. Thus heat may be said to produce electricity, electricity to produce heat; magnetism to produce electricity, electricity magnetism; and so of the rest. Cause and effect, therefore, in their relation to such forces, are words solely of conven-

I myself, without being acquainted with either Mayer or Colding, and having first made the acquaintance of Joule's experiments at the end of my investigation, followed the same path. I endeavored to ascertain all the relations between the different natural processes, which followed from our regarding them from the above point of view. My inquiry was made public in 1847, in a small pamphlet bearing the title, "On the Conservation of Force."*

Since that time the interest of the scientific public for this subject has gradually augmented, particularly in England, of which I had an opportunity of convincing myself during a visit last summer. A great number of the essential consequences of the above manner of viewing the subject, the proof of which was wanting when the first theoretic notions were published, have since been confirmed by experiment, particularly by those of Joule; and during the last year the most eminent physicist of France, Regnault, has adopted the new mode of regarding the question, and by fresh investigations on the specific heat of gases has contributed much to its support. For some important consequences the experimental proof is still wanting, but the number of confirmations is so predominant, that I have not deemed it too early to bring the subject before even a non-scientific audience.

How the question has been decided you may already infer from what has been stated. In the series of natural processes there is no circuit to be found, by which mechanical force can be gained without a corresponding consumption. The perpetual motion remains impossible. Our reflections, however, gain thereby a higher interest.

We have thus far regarded the development of force by natural processes, only in its relation to its usefulness to man, as mechanical force. You now see that we have arrived at a general law, which holds good wholly independent of the application which man makes of natural forces; we must therefore make the expression of our law correspond to this more general significance. It is in the first place clear, that the work which, by any natural process whatever, is performed under favorable con-

ience: we are totally unacquainted with the generating power of each and all of them, and probably shall ever remain so: we can only ascertain the normal of their action: we must humbly refer their causation to one omnipresent influence, and content ourselves with studying their effects, and developing by experiment their mutual relations."

"I have long held an opinion," says Mr. Faraday in 1845, "almost amounting to conviction, in common I believe with many other lovers of natural knowledge, that the various forms under which the forces of matter are made manifest have a common origin, or in other words, are so directly related and mutually dependent, that they are convertible one into another."—Tr.

* A translation of this most important essay appears in the Scientific Memoirs, new series, p. 114.—J. T.

ditions by a machine, and which may be measured in the way already indicated, may be used as a measure of force common to all. Further, the important question arises, if the quantity of force cannot be augmented except by corresponding consumption, can it be diminished or lost? For the purposes of our machines it certainly can, if we neglect the opportunity to convert natural processes to use, but as investigation has proved, not for nature as a whole.

In the collision and friction of bodies against each other, the mechanics of former years assumed simply that living force was lost. But I have already stated that each collision and each act of friction generates heat; and, moreover, Joule has established by experiment the important law, that for every foot-pound of force which is lost a definite quantity of heat is always generated, and that when work is performed by the consumption of heat, for each foot-pound thus gained a definite quantity of heat disappears. The quantity of heat necessary to raise the temperature of a pound of water a degree of the Centigrade thermoneter, corresponds to a mechanical force by which a pound weight would be raised to the height of 1350 feet: we name this quantity the mechanical equivalent of heat. I may mention here that these facts conduct of necessity to the conclusion, that heat is not, as was formerly imagined, a fine imponderable substance, but that, like light, it is a peculiar vibratory motion of the ultimate particles of bodies. In collision and friction, according to this manner of viewing the subject, the motion of the mass of a body which is apparently lost is converted into a motion of the ultimate particles of the body; and conversely, when mechanical force is generated by heat, the motion of the ultimate particles is converted into a motion of the mass.

Chemical combinations generate heat, and the quantity of this heat is totally independent of the time and steps through which the combination has been effected, provided that other actions are not at the same time brought into play. If, however, mechanical work is at the same time accomplished, as in the case of the steam-engine, we obtain as much less heat as is equivalent to this work. The quantity of work produced by chemical force is in general very great. A pound of the purest coal gives, when burnt, sufficient heat to raise the temperature of 8086 lbs. of water one degree of the Centigrade thermometer; from this we can calculate that the magnitude of the chemical force of attraction between the particles of a pound of coal and the quantity of oxygen that corresponds to it, is capable of lifting a weight of 100 pounds to a height of twenty miles. Unfortunately in our steam-engines we have hitherto been able to gain only the smallest portion of this work, the greater part being lost in the shape of heat. The best expansive engines give back as

mechanical work only eighteen per cent of the heat generated by the fuel.

From a similar investigation of all the other known physical and chemical processes, we arrive at the conclusion, that nature, as a whole, possesses a store of force which cannot in any way be either increased or diminished, and that therefore the quantity of force in nature is just as eternal and unalterable as the quantity of matter. Expressed in this form, I have named the general law "The Principle of the Conservation of Force."

We cannot create mechanical force, but we may help ourselves from the general storehouse of nature. The brook and the wind, which drive our mills, the forest and the coal-bed, which supply our steam-engines and warm our rooms, are to us the bearers of a small portion of the great natural supply which we draw upon for our purposes, and the actions of which we can apply as we think fit. The possessor of a mill claims the gravity of the descending rivulet, or the living force of the moving wind, as his possession. These portions of the store of nature are what give his property its chief value.

Further, from the fact that no portion of force can be absolutely lost, it does not follow that a portion may not be inapplicable to human purposes. In this respect the inferences drawn by William Thomson from the law of Carnot are of importance. This law, which was discovered by Carnot during his endeavors to ascertain the relations between heat and mechanical force, —which, however, by no means belongs to the necessary consequences of the conservation of force, and which Clausius was the first to modify in such a manner that it no longer contradicted the above general law,—expresses a certain relation between the compressibility, the capacity for heat, and the expansion by heat, of all bodies. It is not yet considered as actually proved, but some remarkable deductions having been drawn from it and afterwards proved to be facts by experiment, it has attained thereby a great degree of probability. Besides the mathematical form in which the law was first expressed by Carnot, we can give it the following more general expression:—"Only when heat passes from a warmer to a colder body, and even then only partially, can it be converted into mechanical work."

The heat of a body which we cannot cool further, cannot be changed into another form of force; into the electric or chemical force, for example. Thus in our steam-engines we convert a portion of the heat of the glowing coal into work, by permitting it to pass to the less warm water of the boiler. If, however, all the bodies in nature had the same temperature, it would be impossible to convert any portion of their heat into mechanical work. According to this we can divide the total force store of the universe into two parts, one of which is heat, and must con-

tinue to be such; the other, to which a portion of the heat of the warmer bodies, and the total supply of chemical, mechanical, electrical, and magnetical forces belong, is capable of the most varied changes of form, and constitutes the whole wealth of change which takes place in nature.

But the heat of the warmer bodies strives perpetually to pass to bodies less warm by radiation and conduction, and thus to establish an equilibrium of temperature. At each motion of a terrestrial body a portion of mechanical force passes by friction or collision into heat, of which only a part can be converted back again into mechanical force. This is also generally the case in every electrical and chemical process. From this it follows, that the first portion of the store of force, the unchangeable heat, is augmented by every natural process, while the second portion, mechanical, electrical, and chemical force, must be diminished; so that if the universe be delivered over to the undisturbed action of its physical processes, all force will finally pass into the form of heat, and all heat come into a state of equilibrium. Then all possibility of a further change would be at an end, and the complete cessation of all natural processes must set in. The life of men, animals, and plants, could not of course continue if the sun had lost his high temperature, and with it his light,—if all the components of the earth's surface had closed those combinations which their affinities demand. In short, the universe from that time forward would be condemned to a state of eternal rest.

These consequences of the law of Carnot are of course only valid, provided that the law, when sufficiently tested, proves to be universally correct. In the mean time there is little prospect of the law being proved incorrect. At all events we must admire the sagacity of Thomson, who, in the letters of a long-known little mathematical formula, which only speaks of the heat, volume and pressure of the bodies, was able to discern consequences which threatened the universe, though certainly after an infinite period of time, with eternal death.

I have already given you notice that our path lay through a thorny and unrefreshing field of mathematico-mechanical developments. We have now left this portion of our road behind us. The general principle which I have sought to lay before you has conducted us to a point from which our view is a wide one, and aided by this principle, we can now at pleasure regard this or the other side of the surrounding world, according as our interest in the matter leads us. A glance into the narrow laboratory of the physicist, with its small appliances and complicated abstractions, will not be so attractive as a glance at the wide heaven above us, the clouds, the rivers, the woods, and the living beings around us. While regarding the laws which have been deduced

from the physical processes of terrestrial bodies as applicable also to the heavenly bodies, let me remind you that the same force, which, acting at the earth's surface, we call gravity (*Schwere*), acts as gravitation in the celestial spaces, and also manifests its power in the motion of the immeasurably distant double stars which are governed by exactly the same laws as those subsisting between the earth and moon; that therefore the light and heat of terrestrial bodies do not in any way differ essentially from those of the sun, or of the most distant fixed star; that the meteoric stones which sometimes fall from external space upon the earth are composed of exactly the same simple chemical substances as those with which we are acquainted. We need therefore feel no scruple in granting that general laws, to which all terrestrial natural processes are subject, are also valid for other bodies than the earth. We will therefore make use of our law to glance over the household of the universe with respect to the store of force capable of action which it possesses.

A number of singular peculiarities in the structure of our planetary system, indicate that it was once a connected mass with a uniform motion of rotation. Without such an assumption it is impossible to explain why all the planets move in the same direction round the sun, why they all rotate in the same direction round their axes, why the planes of their orbits, and those of their satellites and rings, all nearly coincide, why all their orbits differ but little from circles, and much besides. From these remaining indications of a former state, astronomers have shaped an hypothesis regarding the formation of our planetary system, which, although from the nature of the case it must ever remain an hypothesis, still in its special traits is so well supported by analogy, that it certainly deserves our attention, and the more so, as this notion first found utterance in our own home and within the walls of this town.* It was Kant who, feeling great interest in the physical description of the earth and the planetary system, undertook the labor of studying the works of Newton, and as an evidence of the depth to which he had penetrated into the fundamental ideas of Newton, seized the notion that the same attractive force of all ponderable matter which now supports the motion of the planets, must also aforetime have been able to form from matter loosely scattered in space the planetary system. Afterwards, and independent of Kant, Laplace, the great author of the *Mécanique Céleste*, laid hold of the same thought, and introduced it among astronomers.

The commencement of our planetary system, including the sun, must, according to this, be regarded as an immense nebulous mass which filled the portion of space which is now occu-

* Königsberg.

pied by our system, far beyond the limits of Neptune, our most distant planet. Even now we perhaps see similar masses in the distant regions of the firmament, as patches of nebulæ, and nebulous stars; within our system also, comets, the zodiacal light, the corona of the sun during a total eclipse, exhibit remnants of a nebulous substance, which is so thin that the light of the stars passes through it unenfeebled and unrefracted. If we calculate the density of the mass of our planetary system, according to the above assumption, for the time when it was a nebulous sphere, which reached to the path of the outmost planet, we should find that it would require several cubic miles of such matter to weigh a single grain.

The general attractive force of all matter must, however, impel these masses to approach each other, and to condense, so that the nebulous sphere became incessantly smaller, by which, according to mechanical laws, a motion of rotation originally slow, and the existence of which must be assumed, would gradually become quicker and quicker. By the centrifugal force which must act most energetically in the neighborhood of the equator of the nebulous sphere, masses could from time to time be torn away, which afterwards would continue their courses separate from the main mass, forming themselves into single planets, or, similar to the great original sphere, into planets with satellites and rings, until finally the principal mass condensed itself into the sun. With regard to the origin of heat and light this view gives us no information.

When the nebulous chaos first separated itself from other fixed star masses, it must not only have contained all kinds of matter which was to constitute the future planetary system, but also, in accordance with our new law, the whole store of force which at one time must unfold therein its wealth of actions. Indeed in this respect an immense dower was bestowed in the shape of the general attraction of all the particles for each other. This force, which on the earth exerts itself as gravity, acts in the heavenly spaces as gravitation. As terrestrial gravity when it draws a weight downwards performs work and generates *vis viva*, so also the heavenly bodies do the same when they draw two portions of matter from distant regions of space towards each other.

The chemical forces must have been also present, ready to act; but as these forces can only come into operation by the most intimate contact of the different masses, condensation must have taken place before the play of chemical forces began.

Whether still further supply of force in the shape of heat was present at the commencement we do not know. At all events, by aid of the law of the equivalence of heat and work, we find in the mechanical forces existing at the time to which we refer,

so rich a source of heat and light, that there is no necessity whatever to take refuge in the idea of a store of these forces originally existing.* When through condensation of the masses their particles came into collision and clung to each other, the *vis viva* of their motion would be thereby annihilated, and must reappear as heat. Already in old theories it has been calculated that cosmical masses must generate heat by their collision, but it was far from anybody's thought to make even a guess at the amount of heat to be generated in this way. At present we can give definite numerical values with certainty.

Let us make this addition to our assumption; that, at the commencement, the density of the nebulous matter was a vanishing quantity as compared with the present density of the sun and planets; we can then calculate how much work has been performed by the condensation; we can further calculate how much of this work still exists in the form of mechanical force, as attraction of the planets towards the sun, and as *vis viva* of their motion, and find, by this, how much of the force has been converted into heat.

The result of this calculation† is, that only about the 454th part of the original mechanical force remains as such, and that the remainder, converted into heat, would be sufficient to raise a mass of water equal to the sun and planets taken together, not less than twenty-eight millions of degrees of the Centigrade scale. For the sake of comparison, I will mention that the highest temperature which we can produce by the oxyhydrogen blowpipe, which is sufficient to fuse and vaporize even platina, and which but few bodies can endure, is estimated at about 2000 C. degrees. Of the action of a temperature of twenty-eight millions of such degrees we can form no notion. If the mass of our entire system were pure coal, by the combustion of the whole of it only the 3500th part of the above quantity would be generated. This is also clear, that such a development of heat must have presented the greatest obstable to the speedy union of the masses, that the larger part of the heat must have been diffused by radiation into space, before the masses could form bodies possessing the present density of the sun and planets, and that these bodies must once have been in a state of fiery fluidity. This notion is corroborated by the geological phenomena of our planet; and with regard to the other planetary bodies, the flattened form of the sphere, which is the form of equilibrium of a fluid mass, is indicative of a former state of fluidity. If I thus permit an immense quantity of heat to disappear without compensation from our system, the principle of the conservation of force is not thereby invaded. Certainly for our planet it is lost, but not for

* No necessity for a "Fire-mist."—Tr.

† See note at the end.

the universe. It has proceeded outwards, and daily proceeds outwards into infinite space; and we know not whether the medium which transmits the undulations of light and heat, possesses an end where the rays must return, or whether they eternally pursue their way through infinitude.

The store of force at present possessed by our system is also equivalent to immense quantities of heat. If our earth were by a sudden shock brought to rest in her orbit,—which is not to be feared in the existing arrangement of our system—by such a shock a quantity of heat would be generated equal to that produced by the combustion of fourteen such earths of solid coal. Making the most unfavorable assumption as to its capacity for heat, that is, placing it equal to that of water, the mass of the earth would thereby be heated 11200 degrees: it would therefore be quite fused and for the most part reduced to vapor. If then the earth, after having been thus brought to rest, should fall into the sun, which of course would be the case, the quantity of heat developed by the shock would be four hundred times greater.

Even now from time to time such a process is repeated on a small scale. There can hardly be a doubt that meteors, fireballs, and meteoric stones are masses which belong to the universe, and before coming into the domain of our earth, moved like the planets round the sun. Only when they enter our atmosphere do they become visible and fall sometimes to the earth. In order to explain the emission of light by these bodies, and the fact that for some time after their descent they are very hot, the friction was long ago thought of which they experience in passing through the air. We can now calculate that a velocity of 3000 feet a second, supposing the whole of the friction to be expended in heating the solid mass, would raise a piece of meteoric iron 1000° C. in temperature, or, in other words, to a vivid red heat. Now the average velocity of the meteors seems to be thirty or forty times the above amount. To compensate this, however, the greater portion of the heat is doubtless carried away by the condensed mass of air which the meteor drives before it. It is known that bright meteors generally leave a luminous trail behind them, which probably consists of severed portions of the red-hot surfaces. Meteoric masses which fall to the earth often burst with a violent explosion, which may be regarded as a result of the quick heating. The newly-fallen pieces have been for the most part found hot, but not red-hot, which is easily explainable by the circumstance, that during the short time occupied by the meteor in passing through the atmosphere, only a thin superficial layer is heated to redness, while but a small quantity of heat has been able to penetrate to the interior of the mass. For this reason the red heat can speedily disappear.

Thus has the falling of the meteoric stone, the minute remnant of processes which seem to have played an important part in the formation of the heavenly bodies, conducted us to the present time, where we pass from the darkness of hypothetical views to the brightness of knowledge. In what we have said, however, all that is hypothetical is the assumption of Kant and Laplace, that the masses of our system were once distributed as nebulæ in space.

On account of the rarity of the case, we will still further remark in what close coincidence the results of science here stand with the earlier legends of the human family, and the forebodings of poetic fancy. The cosmogony of ancient nations generally commences with chaos and darkness.

Neither is the Mosaic tradition very divergent, particularly when we remember that that which Moses names heaven is different from the blue dome above us, and is synonymous with space, and that the unformed earth and the waters of the great deep, which were afterwards divided into waters above the firmament and waters below the firmament, resembled the chaotic components of the world.

Our earth bears still the unmistakable traces of its old fiery fluid condition. The granite formations of her mountains exhibit a structure, which can only be produced by the crystallization of fused masses. Investigation still shows that the temperature in mines and borings increases as we descend; and if this increase is uniform, at the depth of fifty miles a heat exists sufficient to fuse all our minerals.* Even now our volcanoes project from time to time mighty masses of fused rocks from their interior, as a testimony of the heat which exists there. But the cooled crust of the earth has already become so thick, that, as may be shown by calculations of its conductive power, the heat coming to the surface from within, in comparison with that reaching the earth from the sun, is exceedingly small, and increases the temperature of the surface only about $\frac{1}{30}$th of a degree Centigrade; so that the remnant of the old store of force which is enclosed as heat within the bowels of the earth, has a sensible influence upon the processes at the earth's surface only through the instrumentality of volcanic phenomena. These processes owe their power almost wholly to the action of other heavenly bodies, particularly to the light and heat of the sun, and partly also, in the case of the tides, to the attraction of the sun and moon.

Most varied and numerous are the changes which we owe to the light and heat of the sun. The sun heats our atmosphere irregu-

* This is not probable. The greater density and consequent better conductivity of the mass, and the elevation of the point of fusion by pressure, established by the researches of Messrs. Hopkins and Fairbairn, would throw the region of liquidity deeper.—Tr.

larly, the warm rarefied air ascends, while fresh cool air flows from the sides to supply its place: in this way winds are generated. This action is most powerful at the equator, the warm air of which incessantly flows in the upper regions of the atmosphere towards the poles; while just as persistently at the earth's surface, the trade-wind carries new and cool air to the equator. Without the heat of the sun, all winds must of necessity cease. Similar currents are produced by the same cause in the waters of the sea. Their power may be inferred from the influence which in some cases they exert upon climate. By them, the warm water of the Antilles is carried to the British Isles, and confers upon them a mild uniform warmth, and rich moisture; while, through similar causes, the floating ice of the North Pole is carried to the coast of Newfoundland and produces raw cold. Further, by the heat of the sun a portion of the water is converted into vapor, which rises in the atmosphere, is condensed to clouds, or falls in rain and snow upon the earth, collects in the form of springs, brooks and rivers, and finally reaches the sea again, after having eroded the rocks, carried away loose earth, and thus performed its part in the geologic changes of the globe; perhaps, besides all this, it has driven our water-mill upon its way. If the heat of the sun were withdrawn, there would remain only a single motion of water, namely, the tides, which are produced by the attraction of the sun and moon.

How is it, now, with the motions and the work of organic beings. To the builders of the automata of the last century, men and animals appeared as clockwork which was never wound up, and created the force which they exerted out of nothing. They did not know how to establish a connexion between the nutriment consumed and the work generated. Since, however, we have learned to discern in the steam-engine this origin of mechanical force, we must inquire whether something similar does not hold good with regard to men. Indeed, the continuation of life is dependent on the consumption of nutritive materials: these are combustible substances, which, after digestion and being passed into the blood, actually undergo a slow combustion, and finally enter into almost the same combinations with the oxygen of the atmosphere that are produced in an open fire. As the quantity of heat generated by combustion is independent of the duration of the combustion and the steps in which it occurs, we can calculate from the mass of the consumed material how much heat, or its equivalent work, is thereby generated in an animal body. Unfortunately, the difficulty of the experiments is still very great; but within those limits of accuracy which have been as yet attainable, the experiments show that the heat generated in the animal body corresponds to the amount which would be generated by the chemical processes. The animal body therefore does

not differ from the steam-engine, as regards the manner in which it obtains heat and force, but does differ from it in the manner in which the force gained is to be made use of. The body is, besides, more limited than the machine in the choice of its fuel; the latter could be heated with sugar, with starch-flour, and butter, just as well as with coal or wood; the animal body must dissolve its materials artificially, and distribute them through its system; it must, further, perpetually renew the used-up materials of its organs, and as it cannot itself create the matter necessary for this, the matter must come from without. Liebig was the first to point out these various uses of the consumed nutriment. As material for the perpetual renewal of the body, it seems that certain definite albuminous substances which appear in plants, and form the chief mass of the animal body, can alone be used. They form only a portion of the mass of nutriment taken daily; the remainder, sugar, starch, fat, are really only materials for warming, and are perhaps not to be superseded by coal, simply because the latter does not permit itself to be dissolved.

If, then, the processes in the animal body are not in this respect to be distinguished from inorganic processes, the question arises, whence comes the nutriment which constitutes the source of the body's force? The answer is, from the vegetable kingdom; for only the material of plants, or the flesh of plant-eating animals, can be made use of for food. The animals which live on plants occupy a mean position between carnivorous animals, in which we reckon man, and vegetables, which the former could not make use of immediately as nutriment. In hay and grass the same nutritive substances are present as in meal and flour, but in less quantity. As, however, the digestive organs of man are not in a condition to extract the small quantity of the useful from the great excess of the insoluble, we submit, in the first place, these substances to the powerful digestion of the ox, permit the nourishment to store itself in the animal's body, in order in the end to gain it for ourselves in a more agreeable and useful form. In answer to our question, therefore, we are referred to the vegetable world. Now when what plants take in and what they give out are made the subjects of investigation, we find that the principal part of the former consists in the products of combustion which are generated by the animal. They take the consumed carbon given off in respiration, as carbonic acid, from the air, the consumed hydrogen as water, the nitrogen in its simplest and closest combination as ammonia; and from these materials, with the assistance of small ingredients which they take from the soil, they generate anew the compound combustible substances, albumen, sugar, oil, on which the animal subsists. Here, therefore, is a circuit which appears to be a perpetual store of

force. Plants prepare fuel and nutriment, animals consume these, burn them slowly in their lungs, and from the products of combustion the plants again derive their nutriment. The latter is an eternal source of chemical, the former of mechanical forces. Would not the combination of both organic kingdoms produce the perpetual motion? We must not conclude hastily: further inquiry shows, that plants are capable of producing combustible substances only when they are under the influence of the sun. A portion of the sun's rays exhibits a remarkable relation to chemical forces,—it can produce and destroy chemical combinations; and these rays, which for the most part are blue or violet, are called therefore chemical rays. We make use of their action in the production of photographs. Here compounds of silver are decomposed at the place where the sun's rays strike them. The same rays overpower in the green leaves of plants the strong chemical affinity of the carbon of the carbonic acid for oxygen, give back the latter free to the atmosphere, and accumulate the other, in combination with other bodies, as woody fibre, starch, oil, or resin. These chemically active rays of the sun disappear completely as soon as they encounter the green portions of the plants, and hence it is that in daguerreotype images the green leaves of plants appear uniformly black. Inasmuch as the light coming from them does not contain the chemical rays, it is unable to act upon the silver compounds.

Hence a certain portion of force disappears from the sunlight, while combustible substances are generated and accumulated in plants; and we can assume it as very probable, that the former is the cause of the latter. I must indeed remark, that we are in possession of no experiments from which we might determine whether the *vis viva* of the sun's rays which have disappeared corresponds to the chemical forces accumulated during the same time; and as long as these experiments are wanting, we cannot regard the stated relation as a certainty. If this view should prove correct, we derive from it the flattering result, that all force, by means of which our bodies live and move, finds its source in the purest sunlight; and hence we are all, in point of nobility, not behind the race of the great monarch of China, who heretofore alone called himself Son of the Sun. But it must also be conceded, that our lower fellow-beings, the frog and leech, share the same etherial origin, as also the whole vegetable world, and even the fuel which comes to us from the ages past, as well as the youngest offspring of the forest with which we heat our stoves and set our machines in motion.

You see, then, that the immense wealth of ever-changing meteorological, climatic, geological, and organic processes of our earth are almost wholly preserved in action by the light and heat-giving rays of the sun; and you see in this a remarkable

example, how Proteus-like the effects of a single cause, under altered external conditions, may exhibit itself in nature. Besides these, the earth experiences an action of another kind from its central luminary, as well as from its satellite the moon, which exhibits itself in the remarkable phenomenon of the ebb and flow of the tide.

Each of these bodies excites, by its attraction upon the waters of the sea, two gigantic waves, which flow in the same direction round the world, as the attracting bodies themselves apparently do. The two waves of the moon, on account of her greater nearness, are about $3\frac{1}{2}$ times as large as those excited by the sun. One of these waves has its crest on the quarter of the earth's surface which is turned towards the moon, the other is at the opposite side. Both these quarters possess the flow of the tide, while the regions which lie between have the ebb. Although in the open sea the height of the tide amounts to only about three feet, and only in certain narrow channels, where the moving water is squeezed together, rises to thirty feet, the might of the phenomena is nevertheless manifest from the calculation of Bessel, according to which a quarter of the earth covered by the sea possesses, during the flow of the tide, about 25,000 cubic miles of water more than during the ebb, and that therefore such a mass of water must, in $6\frac{1}{4}$ hours, flow from one quarter of the earth to the other.

The phenomena of the ebb and flow, as already recognized by Mayer, combined with the law of the conservation of force, stands in remarkable connexion with the question of the stability of our planetary system. The mechanical theory of the planetary motions discovered by Newton teaches, that if a solid body in absolute *vacuo*, attracted by the sun, move around him in the same manner as the planets, this motion will endure unchanged through all eternity.

Now we have actually not only one, but several such planets, which move around the sun, and by their mutual attraction create little changes and disturbances in each other's paths. Nevertheless Laplace, in his great work, the *Mécanique Céleste*, has proved that in our planetary system all these disturbances increase and diminish periodically, and can never exceed certain limits, so that by this cause the eternal existence of the planetary system is unendangered.

But I have already named two assumptions which must be made: first, that the celestial spaces must be absolutely empty; and secondly, that the sun and planets must be solid bodies. The first is at least the case as far as astronomical observations reach, for they have never been able to detect any retardation of the planets, such as would occur if they moved in a resisting medium. But on a body of less mass, the comet of Encke,

changes are observed of such a nature: this comet describes ellipses round the sun which are becoming gradually smaller. If this kind of motion, which certainly corresponds to that through a resisting medium, be actually due to the existence of such a medium, a time will come when the comet will strike the sun; and a similar end threatens all the planets, although after a time, the length of which baffles our imagination to conceive of it. But even should the existence of a resisting medium appear doubtful to us, there is no doubt that the planets are not wholly composed of solid materials which are inseparably bound together. Signs of the existence of an atmosphere are observed on the Sun, on Venus, Mars, Jupiter, and Saturn. Signs of water and ice upon Mars; and our earth has undoubtedly a fluid portion on its surface, and perhaps a still greater portion of fluid within it. The motions of the tides, however, produce friction, all friction destroys *vis viva*, and the loss in this case can only affect the *vis viva* of the planetary system. We come thereby to the unavoidable conclusion, that every tide, although with infinite slowness, still with certainty, diminishes the store of mechanical force of the system; and as a consequence of this, the rotation of the planets in question round their axes must become more slow, they must therefore approach the sun, or their satellites must approach them. What length of time must pass before the length of our day is diminished one second by the action of the tides cannot be calculated, until the height and time of the tide in all portions of the ocean are known. This alteration, however, takes place with extreme slowness, as is known by the consequences which Laplace has deduced from the observations of Hipparchus, according to which, during a period of 2000 years, the duration of the day has not been shortened by the $\frac{1}{3\,6\,6}$th part of a second. The final consequence would be, but after millions of years, if in the mean time the ocean did not become frozen, that one side of the earth would be constantly turned towards the sun, and enjoy a perpetual day, whereas the opposite side would be involved in eternal night. Such a position we observe in our moon with regard to the earth, and also in the case of the satellites as regards their planets; it is, perhaps, due to the action of the mighty ebb and flow to which these bodies, in the time of their fiery fluid condition, were subjected.

I would not have brought forward these conclusions, which again plunge us in the most distant future, if they were not unavoidable. Physico-mechanical laws are, as it were, the telescopes of our spiritual eye, which can penetrate into the deepest night of time, past and to come.

Another essential question as regards the future of our planetary system has reference to its future temperature and illumi-

nation. As the internal heat of the earth has but little influence on the temperature of the surface, the heat of the sun is the only thing which essentially affects the question. The quantity of heat falling from the sun during a given time upon a given portion of the earth's surface may be measured, and from th s it can be calculated how much heat in a given time is sent out from the entire sun. Such measurements have been made by the French physicist Pouillet, and it has been found that the sun gives out a quantity of heat per hour equal to that which a layer of the densest coal 10 feet thick would give out by its combustion; and hence in a year a quantity equal to the combustion of a layer of 17 miles. If this heat were drawn uniformly from the entire mass of the sun, its temperature would only be diminished thereby $1\frac{1}{3}$d of a degree Centigrade per year, assuming its capacity for heat to be equal to that of water. These results can give us an idea of the magnitude of the emission, in relation to the surface and mass of the sun; but they cannot inform us whether the sun radiates heat as a glowing body, which since its formation has its heat accumulated within it, or whether a new generation of heat by chemical processes takes place at the sun's surface. At all events the law of the conservation of force teaches us that no process analogous to those known at the surface of the earth, can supply for eternity an inexhaustible amount of light and heat to the sun. But the same law also teaches that the store of force at present existing, as heat, or as what may become heat, is sufficient for an immeasurable time. With regard to the store of chemical force in the sun, we can form no conjecture, and the store of heat there existing can only be determined by very uncertain estimations. If, however, we adopt the very probable view, that the remarkably small density of so large a body is caused by its high temperature, and may become greater in time, it may be calculated that if the diameter of the sun were diminished only the ten-thousandth part of its present length, by this act a sufficient quantity of heat would be generated to cover the total emission for 2100 years. Such a small change besides it would be difficult to detect even by the finest astronomical observations.

Indeed, from the commencement of the period during which we possess historic accounts, that is, for a period of about 4000 years, the temperature of the earth has not sensibly diminished. From these old ages we have certainly no thermometric observations, but we have information regarding the distribution of certain cultivated plants, the vine, the olive tree, which are very sensitive to changes of the mean annual temperature, and we find that these plants at the present moment have the same limits of distribution that they had in the times of Abraham and Homer; from which we may infer backwards the constancy of the climate.

In opposition to this it has been urged, that here in Prussia the German knights in former times cultivated the vine, cellared their own wine and drank it, which is no longer possible. From this the conclusion has been drawn, that the heat of our climate has diminished since the time referred to. Against this, however, Dove has cited the reports of ancient chroniclers, according to which, in some peculiarly hot years, the Prussian grape possessed somewhat less than its usual quantity of acid. The fact also speaks not so much for the climate of the country as for the throats of the German drinkers.

But even though the force store of our planetary system is so immensely great, that by the incessant emission which has occurred during the period of human history it has not been sensibly diminished, even though the length of the time which must flow by, before a sensible change in the state of our planetary system occurs, is totally incapable of measurement, still the inexorable laws of mechanics indicate that this store of force, which can only suffer loss and not gain, must be finally exhausted. Shall we terrify ourselves by this thought? Men are in the habit of measuring the greatness and the wisdom of the universe by the duration and the profit which it promises to their own race; but the past history of the earth already shows what an insignificant moment the duration of the existence of our race upon it constitutes. A Nineveh vessel, a Roman sword awakes in us the conception of grey antiquity. What the museums of Europe show us of the remains of Egypt and Assyria we gaze upon with silent astonishment, and despair of being able to carry our thoughts back to a period so remote. Still must the human race have existed for ages, and multiplied itself before the pyramids of Nineveh could have been erected. We estimate the duration of human history at 6000 years; but immeasurable as this time may appear to us, what is it in comparison with the time during which the earth carried successive series of rank plants and mighty animals, and no men; during which in our neighborhood the amber-tree bloomed, and dropped its costly gum on the earth and in the sea; when in Siberia, Europe and North America groves of tropical palms flourished; where gigantic lizards, and after them elephants, whose mighty remains we still find buried in the earth, found a home? Different geologists, proceeding from different premises, have sought to estimate the duration of the above creative period, and vary from a million to nine million years. And the time during which the earth generated organic beings is again small when we compare it with the ages during which the world was a ball of fused rocks. For the duration of its cooling from 2000° to 200° Centigrade, the experiments of Bishop upon basalt show that about 350 millions of years would be necessary. And with regard to

the time during which the first nebulous mass condensed into our planetary system, our most daring conjectures must cease. The history of man, therefore, is but a short ripple in the ocean of time. For a much longer series of years than that during which man has already occupied this world, the existence of the present state of inorganic nature favorable to the duration of man seems to be secured, so that for ourselves and for long generations after us we have nothing to fear. But the same forces of air and water, and of the volcanic interior, which produced former geological revolutions, and buried one series of living forms after another, act still upon the earth's crust. They more probably will bring about the last day of the human race than those distant cosmical alterations of which we have spoken, and perhaps force us to make way for new and more complete living forms, as the lizards and the mammoth have given place to us and our fellow-creatures which now exist.

Thus the thread which was spun in darkness by those who sought a perpetual motion has conducted us to a universal law of nature, which radiates light into the distant nights of the beginning and of the end of the history of the universe. To our own race it permits a long but not an endless existence; it threatens it with a day of judgment, the dawn of which is still happily obscured. As each of us singly must endure the thought of his death, the race must endure the same. But above the forms of life gone by, the human race has higher moral problems before it, the bearer of which it is, and in the completion of which it fulfills its destiny.

Note to page 205.—I must here explain the calculation of the heat which must be produced by the assumed condensation of the bodies of our system from scattered nebulous matter. The other calculations, the results of which I have mentioned, are to be found partly in J. R. Mayer's papers, partly in Joule's communications, and partly by aid of the known facts and method of science: they are easily performed.

The measure of the work performed by the condensation of the mass from a state of infinitely small density, is the potential of the condensed mass upon itself. For a sphere of uniform density of the mass M, and the radius R, the potential upon itself V—if we call the mass of the earth m, its radius r, and the intensity of gravity at its surface g,—has the value

$$V=\frac{3}{5}\cdot\frac{r^2M^2}{Rm}\cdot g.$$

Let us regard the bodies of our system as such spheres, then the total work of condensation is equal to the sum of all their potentials on themselves. As, however, these potentials for different spheres are to each other as the quantity $\frac{M^2}{R}$, they all vanish in comparison with the sun; even that of the greatest planet, Jupiter, is only about the one hundred-thousandth part of that of the sun; in the calculation, therefore, it is only necessary to introduce the latter.

To elevate the temperature of a mass M of the specific heat σ, t degrees, we need a quantity of heat equal to $M\sigma t$; this corresponds, when Ag represents the mechanical equivalent of the unit of heat, to the work $AgM\sigma t$. To find the elevation of temperature produced by the condensation of the mass of the sun, let us set

$$AgM\sigma t = V;$$

we have then

$$t = \frac{3}{5} \cdot \frac{r^2 M}{A \cdot R_\cdot \cdot m \cdot \sigma}.$$

For a mass of water equal to the sun we have $\sigma = 1$; then the calculation with the known values of A, M, R, m, and r, gives

$$t = 28611000° \text{ Cent.}$$

The mass of the sun is 738 times greater than that of all the planets taken together; if, therefore, we desire to make the water-mass equal to that of the entire system, we must multiply the value of t by the fraction $\frac{738}{739}$, which makes hardly a sensible alteration in the result.

When a spherical mass of the radius R condenses more and more to the radius R_1, the elevation of temperature thereby produced is

$$\vartheta = \frac{3}{5} \cdot \frac{r^2 M}{A \cdot m\sigma}\left(\frac{1}{R_1} - \frac{1}{R_0}\right), \quad \text{or} \quad = \frac{3}{5} \cdot \frac{r^2 M}{A R_1 m\sigma}\left(1 - \frac{R_1}{R_0}\right).$$

Supposing, then, the mass of the planetary system to be at the commencement, not a sphere of infinite radius, but limited, say of the radius of the path of Neptune, which is six thousand times greater than the radius of the sun, the magnitude $\frac{R_1}{R_0}$ will then be equal to $\frac{1}{6000}$, and the above value of t would have to be diminished by this inconsiderable amount.

From the same formula, we can deduce that a diminution of $\frac{1}{1000}$ of the radius of the sun would generate work in a water mass equal to the sun, equivalent to 2861 degrees Centigrade. And as, according to Pouillet, a quantity of heat corresponding to $1\frac{1}{4}$ degree is lost annually in such a mass, the condensation referred to would cover the loss for 2289 years.

If the sun, as seems probable, be not everywhere of the same density, but is denser at the centre than near the surface, the potential of its mass and the corresponding quantity of heat will be still greater.

Of the now remaining mechanical forces, the *vis viva* of the rotation of the heavenly bodies round their own axes is, in comparison with the other quantities, very small, and may be neglected. The *vis viva* of the motion of revolution round the sun, if μ be the mass of a planet, ϱ its distance from the sun, is

$$L = \frac{gr^2 M\mu}{m}\left(\frac{1}{R} - \frac{1}{2\varrho}\right).$$

Omitting the quantity $\frac{1}{2\varrho}$ as very small compared with $\frac{1}{R}$, and dividing by the above value of V, we obtain $\frac{L}{V} = \frac{5}{3}\frac{\mu}{M}$.

The mass of all the planets together is $\frac{1}{738}$ of the mass of the sun, hence the value of L for the entire system is $L = \frac{1}{453} \cdot V$.

ART. XVI.—*On the Formation of Craters, and the Nature of the Liquidity of Lavas;** by G. POULETT SCROPE, Esq., M.P., F.R.S., F.G.S.

II. *The nature of the liquidity of lavas.*—So much for that branch of my subject,—the formation of cones and craters. I wish now to ask attention to some circumstances respecting the mode of emission and nature of the lavas that proceed from them. I have already spoken of the comparatively tranquil manner in which some lava-streams are seen to well out from the flank of a volcano, or its summit, and the probability that differences in the liquidity or viscosity of the heated matter at the time of its efflux may occasion corresponding differences in the character of the phenomena. Observation confirms this expectation; and it has been remarked, that the very liquid and vitrified lavas, such as those of Kilauea and Bourbon, are poured out more or less tranquilly without any very violent explosions, their imprisoned vapors evidently escaping with comparative ease, while the more viscous and ultimately stony lavas, possessing a minor degree of liquidity, and consequently not allowing so easy a passage to the vapors that rise through, and struggle to escape from them, are protruded with fiercer explosive bursts, and the ejection of far greater quantities of scoria and other fragmentary matters.

This observation, coupled with other reasons to which I shall presently advert, led me to an opinion expressed in the works above referred to, that the ordinary crystalline or granular lavas (making exception of the vitreous varieties), although at a white heat at the moment of their emission from a volcanic vent, are not in a state of complete fusion; that a large proportion, at least, if not all, of the crystalline or granular particles of which, when cooled and consolidated, they appear composed, are already formed and solid, their mobility being aided by the intimate dissemination through the mass of a minute but appreciable quantity of some fluid,—in all probability water,—which is prevented from expanding wholly into vapor by the pressure to which it is subjected while within the volcanic vent, or in the interior of the current, until that pressure is sufficiently reduced to allow of its expansion into bubbles, or its escape through pores or cracks, by which it passes into the open air from the surface of the intumescent lava.

I was strengthened in this opinion by several concurrent considerations:—

1. If all lavas are (as they are usually supposed to be) in a state of complete fusion when they issue from a volcano, how is

* Concluded from vol. xxiii, p. 359.

it that they do not all present the same glassy texture which is seen in some, the obsidians, pitchstones, and pumiceous lavas especially, and in the ropy, cavernous, filamentous basalts of Kilauea, Iceland, and Bourbon, and which these very crystalline and stony lavas themselves put on when melted under the blowpipe or in a furnace? The usual answer is, that the granular and crystalline texture is acquired subsequently to emission by slow cooling; and the experiments of Gregory Watt and Sir James Hall are cited in support of this assertion. In the present day, probably the process by which Messrs. Chance & Co., of Birmingham, devitrify a mass of fused basalt (from the Rowley rag, near Dudley) by causing it to cool slowly in an "annealing furnace," would be considered as a strong confirmatory fact.

But there is no fact more certain than this, that the superficial portions, at least, of a lava-current flowing in the open air, do not cool slowly. On the contrary, they are rapidly, I might say instantaneously, upon their exposure, consolidated and cooled down to a temperature which permits them to be handled and even walked upon without damage. How is it that this scoriform crust, or the solid cakes and slabs which so instantly form upon every exposed surface of lava, nay, even the scoria which is tossed up in a liquid state by the eruptive jets, and harden while yet in the air before they fall, exhibit on fracture no glassy texture, but much the same earthy or stony grain, and occasionally crystals of considerable size in the solid matter separating their cellular cavities, as is found in the interior of the current which is known to have cooled very slowly? How is it that some lava currents are stony throughout, others vitreous throughout, as, for example, some of the large pumice-streams of Lipari, Iceland, and the Andes?

I have recently visited the manufactory of the Messrs Chance, at Oldbury, near Birmingham, for the purpose of examining the mode in which the basalt used there (and which is the same upon which Mr. Gregory Watt experimented) conducts itself in their furnaces, and I found, that when the liquid and fused contents of a furnace at a white heat is poured out upon a brick or other floor into the open air, so as to represent a stream of lava flowing out of a volcanic vent, it consolidates throughout, whatever its bulk, into a homogeneous and purely vitreous black obsidian, in fact, an absolute glass, with a conchoidal fracture and sharp cutting edges. It is only when made to consolidate very slowly in an oven kept at a high temperature for some days, that it assumes the deadened and semi-crystalline texture of the manufactured article.

If this process be interrupted, it is found to have commenced by the formation, at numerous points within the vitreous mass, of globular concretions about the size of a small pea, of a lighter color than the base, and having a pearly lustre and radiated

structure. The multiplication and confusion of these crystallites or sphærulites ultimately destroy the glassy character of the substance altogether, and give to it a pearly semi-crystalline texture, without, however, restoring the far more crystalline aspect of the basaltic rock. A similar change may be often observed to have taken place in nature among the vitreous lavas, which pass into pearlstone and pitchstone by the formation of the same kind of sphærulitic concretions, and of course there is no question as to the complete state of fusion in which such lavas have been produced. But there is no trace of such a process in any of the ordinary earthy, and stony or crystalline and porphyritic lavas. I am not aware of a single current from either Etna or Vesuvius having ever exhibited, even on its most rapidly cooled surfaces, any passage into true obsidian, or sphærulitic pearlstone, or any portion of such vitrifactions. A pellicle, or glaze, of a semi-vitreous appearance coats the surface in some parts, or lines the cellular cavities; but it seems evident that the bulk of the matter could not have been at the time of its emission in that thoroughly fused condition which it assumes when melted in a furnace or under the blowpipe.

2. It struck me that temperature does not alone determine the fusion or liquefaction of substances; and that compression may prevent the liquefaction of a solid at a high temperature, just as it prevents the vaporization of a liquid, in the common experiment of boiling water at a lower temperature in a rarefied atmosphere. If so, the intense pressure to which heated lava must be subjected before it rises from the bowels of the earth to discharge itself on the surface, intensified by the reaction of its own expansive force from the confining surfaces, might perhaps prevent its complete fusion, however high the temperature.

3. I had long been impressed by the vast volumes of aqueous and other elastic vapors evidently discharged from every volcano in eruption, and to all appearance the chief agents in the expulsion of lavas from the bowels of the earth. That this vapor is liable to be developed in every part of the mass of lava is shown by the formation of vesicles throughout its substance wherever the pressure is so reduced as to permit their expansion; for instance, in the superficial portions of a current; and in some lava-currents throughout the entire mass.

The experiments of Mr. Knox, related in a paper read before the Royal Society in 1824,* had taught me that water in an appreciable quantity is mechanically combined with the elementary particles of all the crystalline rocks of igneous origin. The question, therefore, arose,— Might not the water thus intimately disseminated through a mass of crystalline lava, although at an intense temperature, remain unvaporized owing to the still greater

* Phil. Trans., 1825.

intensity of the pressure by which it is confined while yet within the bowels of the earth? and would it not under these circumstances exert an intense expansive force upon all the confining molecular or crystalline surfaces between which it lies, and thus occasion a tendency to separation among these solid particles whenever the compressing forces were relaxed, or the temperature increased sufficiently, so as to give a certain degree of mobility to these particles *inter se*, and an imperfect liquidity to the mass composed of them? And, supposing the intumescence thus occassioned to raise any portion of this semi-liquid matter into the open air, would not the instantaneous absorption of caloric from the contiguous particles, that must accompany the vaporization of this water, and its escape in bubbles or pores and through cracks, owing to the nearly absolute cessation of pressure, account for the sudden cooling down and *setting*, or consolidation, of the exposed surfaces, without having undergone complete fusion (except in the case of mere superficial films), notwithstanding their previous intense temperature, amounting even to a white heat?

This supposition seemed to me to account satisfactorily, not only for the absence of a vitreous texture even in superficial portions of many lava-streams, and their instantaneous consolidation on exposure, in cellular or porous slabs and cakes, but also for several other characteristics of igneous rocks, not easily to be reconciled with the idea of their having always issued from the earth in a state of absolute fusion; such, for example, as the cracked and vitrified aspect of the feldspar-crystals of many trachytes, the broken and dislocated appearance of the leucites, feldspars, and other crystals in many basalts; the frequent arrangement of their longest axes in the direction of the bed of the rock, that is, of the movement of the lava when liquefied; the finer grain often exhibited towards the tail or extremity of a current than at its source, the brecciated lavas which appear to have enveloped fragments in great number of the same material without any fusion even of their finest angles. So also might be explained the more or less spongy, porous, and loosely crystalline texture of many trachytes, and their disposition in thick beds or dome-shaped bosses, attesting their protrusion in a very imperfect state of liquidity, more resembling the intumescence of some kinds of dough in an oven than the fusion of metal in a furnace.

And here let me remark, that Dr. Daubeny, and some other writers on volcanic phenomena, have spoken of the vesicles or air-bladders in lavas, as being proofs of their having been in a state of complete fusion. But have the loaves baked in our ovens been in fusion? The comparison of a cellular scoria with a loaf or a French roll, will show that vesicles of precisely simi-

lar appearance to those of lava are producible in substances of a pasty consistence, which owe their liquidity to an aqueous vehicle, the heat applied being only sufficient to develop the contained gases. Other kinds of baked cakes are porous rather than cellular, and aptly represent the texture of the earthy and porous trachytic lavas.

Plutonic rocks.—This theory as to the nature of the liquidity of many lavas appeared to me to be so reasonable, that I proceeded to examine its applicability to the still more generally crystalline plutonic rocks, from the alteration of which by heat lavas are usually supposed to derive. I asked myself, what would probably be the effect, on a mass of granite, for example, containing water intimately combined with its molecular particles, and confined beneath overlying rocks and seas, under circumstances of intense compression, and at the same time high and increasing temperature? Surely a tendency to intumescence, which, wherever, and in proportion to the extent to which it takes place, must elevate and fracture the overlying rocks, and likewise disintegrate more or less the crystalline particles of the swelling mass, through the irregularities of their internal movements and mutual friction. Many of the crevices broken through the neighboring rocks would be injected by the intumescent matter. Some may be sufficiently enlarged to allow of its forcing its way into the open air as a lava, perhaps accompanied by eructations of the gases and vapors developed in the lower parts of the mass, or, should the liquefaction not be sufficient to admit of the rise of aëriform bubbles, as matter of a porous, pasty, or glutinous consistency, perhaps even semisolid in texture and bulky in form.

It might happen that, circumstances occasioning in turn the preponderance of the compressing over the expansive forces (by reason, for example, of a diminution of temperature), portions of the subterranean crystalline mass will, after a partial intumescence of the kind supposed, return to a state of solidity. The result may be a more fine-grained rock, owing to the partial disintegration of the crystals; or, if the disintegration had proceeded sufficiently far, new mineral combinations might take place. Indeed, Watt long since proved that the particles of even apparently solid rocks are capable, through changes in temperature, of internal motion sufficient to admit their rearrangement according to polarity, that is, of crystallization. Still more likely is this result to occur on the condensation or escape of any fluid which had previously kept them from contact with each other, since the crystalline polarity can only exert itself within minute distances. And thus might we account for the frequently observed passages of granite and gneiss into svenite, greenstone, trap, or trachyte, and the varieties of mineral composition which

these rocks at times exemplify. So also the transitions from the larger crystalline grain to the finer, and the dykes and veins which these rocks so often contain themselves, or intrude into their neighbors. So too the finer grains of the sides, or selvages, of such dykes might be owing to the greater disintegration of the crystals by friction along these sides as the matter was driven through them.

Another problematical fact which this theory of an aqueous vehicle in heated granite would account for, is the usual appearance of the quartz in this rock, not in crystals, but as a paste or base, seeming to be moulded upon the crystals of feldspar. Had the rock crystallized from a state of fusion, the feldspar, being far more fusible than quartz, might have been expected to be the last, not the first, to crystallize. But if the water disseminated through the rock were supposed to have taken the quartz into solution by aid of the alkalies present in the feldspar, the fluid vehicle would in fact become a liquid or gelatinous silicate; and upon consolidation would naturally mould itself on the feldspar crystals, or appear as a paste to them. I adduced the hot siliceous springs of Iceland and other volcanic districts as proofs that heated water under such circumstances could dissolve silex.

Those who will take the trouble to refer to the 2nd, 4th, 5th, and 6th chapters of my "Considerations on Volcanos," will see that the above is a brief summary of the arguments there put forth, perhaps at too great length, and in a form which may have hindered their obtaining at the time of their publication the attention which I believe they merited.

Certain it is, that they were at that time, now thirty years back, neglected, or generally discredited. I was told that my views were "unchemical." I was represented as asserting incandescent lava to be "cold or thereabouts."* The igneous and the aqueous origin of certain rocks had been so hotly contested, and fire and water were usually considered so antagonistic, that it seemed at first view an absurdity to imagine that both could be combined in a substance seemingly in fusion. Probably also the idea was scouted at first through the notion that water could not be present within an incandescent mass of lava without causing it to explode like a mine; which might of course be the result of any considerable body of water being localized at one point. But the view I entertained, as has been explained, was that the water (and to some extent, perhaps, liquefied gases), to which I attributed much of the liquidity of some lavas, was disseminated throughout its mass, occupying minute interstices, and in intimate, though probably mechanical, combination with every molecule,—indeed intercalated between the plates even of its solid crystals; and moreover that the pressure to which the rock

* Westminister Review.

was subjected while beneath the earth was so enormous, as to prevent the vaporization of these minute portions of liquid anywhere except at points, where the intensity of temperature and consequently of expansive force overcame the resisting forces, and thereby caused either the formation and rise of great bubbles of vapor from the lower depths of the subterranean lava-mass, or the inflation of minor bubbles and pores throughout it, or at least in the superficial portions which by intumescence were forced into the open air.

Of late, however, views precisely in accordance with the theory printed by me in 1824 have been put forward, and have attained extensive adhesion among continental geologists.

M. Delesse has proved by experiment the solubility of the silex of rocks in heated water containing either of the mineral alkalies. And, indeed, the manufacture of artificial stone is now carried on in this country (Messrs. Ransom's process) by saturating loose sand with an artificial hydrate of silica. Huge blocks of flint, I understand, are thrown into the hot alkaline water, and melt down like so much sugar.

Again, the experiments of Boutigny have shown that water at a white heat remains unvaporized, in the form of spheroidal globules, in which form it is obvious how readily it would communicate mobilty to the solid particles among which it was entangled; and how (according to these experiments) it might flash into bubbles of vapor on the reduction of its temperature by exposure to the air.

M. Deville, in his recent observations on the vapors disengaged from Vesuvius since the eruption of May in last year (for the perusal of which I am indebted to the kindness of my friend Dr. Daubeny), arrived at the conclusion, to use his own words, that "water in the proportion occasionally of 999 per mille must have formed an integral part of the Vesuvian lava at the moment of its emission; and consequently, that in the interior of the incandescent lava there is such an arrangement of molecules, as to permit the gaseous and volatile matters to remain there imprisoned, until in the progress of cooling and consolidation, they evolve themselves."

Above all, M. Scheerer, of Christiana, the eminent Norwegian geologist, who is better acquainted perhaps than any other with the granites of that country, published in 1847 a theory, which, he says, his observations had suggested to him in 1833, on the production of granite, entirely identical with that which I had ventured to suggest in 1824–25. I take the following account of it from the paper read before the Geological Society of France in 1847, and published in the fourth volume of the Bulletin de la Soc. Géol., p. 468.

M. Scheerer attributes what he calls the "plasticity" of granite when protruded on or towards the surface of the earth (a condition evidenced by the veins it throws into the fissures of neighboring rocks) to the combined action of *water* and heat. He describes the water as "intercalated between the solid atoms of the crystalline and other constituent minerals, endeavoring to escape by its tendency to vaporization, and consequent elasticity, but unable to do so owing to the pressure to which the enclosing mass is subject." He considers the water so contained in granite to be "primitive," that is, one of the original bases of the rock, and not the result of infiltration. He attributes to it the solution of the quartz, aided by the alkali, and the consequent moulding of this mineral on the feldspar crystals. He even goes the length of styling the condition of granite before its protrusion by the term "une bouillie aqueuse," *a granitic broth.*

These theoretical opinions of M. Scheerer appear to have received the assent of M. Elie de Beaumont and other French geologists.* Their exact conformity with those which were first developed in my treatise on Volcanos, published in 1824–25, and repeated in the preface to my volume on Central France in 1826–27, will be evident to any one who will take the trouble to refer to those works.

It is not, however, for the vain purpose of claiming a priority in these views, that I now ask the attention of the Society to them, but because the subject has not, I think, yet attained the consideration I think it deserves from the geologists of this country; and especially because of its leading, if followed out, to further inferences of considerable importance, which were likewise suggested by me in 1825, but have been hitherto only partially pursued to their legitimate consequences.

Laminated or schistose rocks, slaty cleavage, and folded rocks.—I refer to the mechanical changes in the texture and structure of the plutonic rocks which could not fail to have resulted from the mutual friction of the component crystalline particles attendant on their internal movements, whether caused by mere dilatation and re-compression in place, or by a shifting of the entire mass in any direction, under intense and opposite, but irregular pressures.

I was led to reflect on this by observation of the ribboned pitchstones of Ponza and Ischia, in which, while in a state of vitreous fusion, crystallites had formed (just like those of the Oldbury obsidian), and subsequently been broken up by the movement of the semi-liquid mass, and drawn out into long stripes, giving a ribboned appearance to the rock.

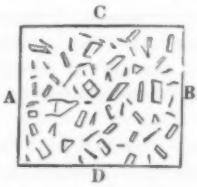
Further examination proved to me that the ribboned trachytes of Ponza and Ischia, and some ribboned clinkstones, owed that

* See Bulletin de la Soc. Géol. France, new series, vol. iv, p. 1312.

character to a similar elongation of the feldspar crystals and feldspathic particles which they previously contained, in the direction in which the semi-liquid mass flowed, or rather was forced to move, and in which the pores or cells, when there are any, are equally elongated. These observations suggested to my mind the reflection that the solid particles of any crystalline rock which is put in motion while in a state of imperfect solidity, and under the influence of opposing pressures, must be subject to a great amount of mutual friction or disturbance, by which their final arrangement when wholly consolidated will be determined.

Thus suppose a mass of granite, of which A B (fig. 4) repre-

4.



5.

sents the section, consisting of crystals of feldspar and mica irregularly dispcsed in a bases of more or less liquified or gelatinous silex, exposed to movement in the direction A B, while under vast pressure both from above and below, that is in the opposite directions C and D. Whether the surface, C, or D, or both, remained fixed, or merely moved, owing to resistances, at a slower rate than the other parts, the crystals in the latter would be turned round by internal friction, and rearranged and drawn out in stripes or planes in the direction of the motion, while the proportionate dimensions of the mass would be equally varied so as to produce a section something like E, F, G, H, (fig. 5), in fact, a rock which, if no further change occurred in it except consolidation in place, would have all the characteristics of *gneiss*. The same movement, if still further continued, might, it appeared to me, be expected to disintegrate the angular crystals of felspar altogether, so as to cause them to disappear, perhaps to force their elementary molecules to melt into the intensely heated silicate, to which they would impart their alkalies. And the resulting rock, supposing the laminæ of the mica-crystals to slide readily past each other, when lubricated by the silicate, and not therefore to be so far disintegrated as those of feldspar (as from their peculiar form might be expected), would put on a lamellar structure, and very much resemble *mica-schist*,—especially since the great flexibility of the mica would render its laminæ extremely liable to yield to the irregularities of pressure pervading the mass, in a variety of directions, and consequently to take

such wavings and contortions as are often exemplified in that rock. Whoever will examine the tortuous way in which the plates of mica envelope and bend round nodules of half-melted quartz or crystals of garnet in mica-schist, will be convinced, I think, that the whole mass has been subjected to great internal movement and consequent friction in the direction of the layers of mica, while under intense pressure, and in a comparatively softened state, the mica being lubricated, as it were, by a vehicle of liquid or gelatinous quartz. Whatever fissures or cracks were formed during this movement in the semi-solid rock, or subsequently, so long as the silicate remained unconsolidated, would be necessarily filled by it, and ultimately appear in the shape of the quartz-veins so frequent in this class of rocks.

Under this supposition gneiss and mica-schist would bear the same relation to granite as the ribboned trachytes and schistose lavas (clinkstone) to ordinary crystallized or granular trachyte; and the quartz rocks associated with granite, represent the quartzose trachytes of Hungary, Ponza, and the Andes.

These views, developed by me in 1825, I cannot but think, deserve the attention of geologists engaged in investigating the origin of the so-called "plutonic" and "metamorphic" rocks. It seems to me more probable that some process of this kind may have metamorphosed granite into the laminated rocks of plutonic origin, gneiss, and mica-schist, than that these rocks should have been formed by the mere fusion and reconsolidation or crystallization in place of sedimentary strata *already laminated*, according to the usual "metamorphic" doctrine. I can understand the clay-slates and other fine-grained schists to have been formed through the mechanical disintegration of mica-schist, but not mica-schist by the baking or melting and cooling of the clay-slates in place, in the manner suggested by Sir C. Lyell.

In the formation of the clay-slates, perhaps, the action of heat was not concerned (except as engendering the pressure to which they have evidently been subjected), but that of water or an aqueous silicate only. Still in their case also internal movements and mutual friction of the component particles under extreme and irregular opposing pressures have, I am convinced, had a primary influence in occasioning that parallel arrangement of the scaly and flaky micaceous particles to which their slaty cleavage is due. This, at least, was the conviction forced upon my mind by a close examination of the fissile clinkstone of the Mont Dor and Mezen, which is used for roofing-slate, and is in its lamination and cleavage undistinguishable from many clay-slates. And that opinion I recorded at the time in my 'Considerations on Volcanos.'*

* See pp. 103, 144, and 202.

I have since found this view of the origin of slaty cleavage supported by Mr. Darwin in his work on 'Volcanic Islands,' and by Mr. Sorby in his paper on slaty cleavage in the Edinburgh Philosophical Journal for 1853. I need not say that such support affords strong confirmation of its correctness.

Of course we are led to connect the movements under extreme pressure, to which this peculiar texture of the laminated rocks is here attributed, with the action of those same forces by which their beds have been so generally bent and contorted into a series of folds or wrinkles, more or less at right angles to the general strike.

If we seek to discover under what circumstances these flexures were brought about, we can hardly be wrong in ascribing them to the same violent process by which they have been elevated, usually on the flanks of some protruded ridge or enormous dyke of crystalline rock, which is seen to form the axis of the mountain range to which they belong.

Now what may we suppose to have been the character of this elevatory process?

The phenomena of active volcanos, and the protrusion of intumescent crystalline matter on so many points of the earth's surface, and at all periods of its history, may be admitted to prove the continued existence beneath a very large area of that surface—if not the whole—of a mass of intensely heated crystalline matter, having disseminated throughout its substance (in the manner already dwelt upon) some fluid or fluids, such as water, affording an imperfect liquidity to the mass, and by its intense elastic force, communicating to it a powerful tendency to expansion. Now suppose any considerable diminution to occur locally in the amount of pressure confining this expansible mass beneath the crust of the globe,—such as might be brought about by an extraordinary concurrence of the ordinary barometric, tidal, oceanic, or excavating causes, (not to suggest others),—or, on the other hand, any considerable increase of its expansive tendency, owing to a local increase of temperature, from some unknown, but easily imagined, cause,—we should anticipate, as the necessary result, the violent fracture and elevation of the overlying crust of rocks, and the extrusion through some principal fissure, or line of fracture, of a ridge of the subterranean intumescent crystalline matter.

It seems very probable that under such circumstances the central axis of the protruded ridge may retain its irregularly crystalline grain and structure, but that the portions of crystalline matter that from either side would rush or be thrust up by pressure from behind (consisting partly of the weight of the overlying rocks on the semi-liquid matter below them) towards the opening should be subjected to so much internal friction of their crystal-

line particles, and so much pressure at right angles, or nearly so, to the direction of the movement, as must stretch and draw them out into parallel planes,—just as happened evidently to the striped and ribboned trachytes in the protruded dykes of Ponza and Palmarola. This friction and pressure would be extreme, of course, along the lateral parts of the protruded mass, that is, the selvages of the great dyke; which, if the original mass were granite, would thus appear composed of an axis of granite, passing on either side into gneiss (or squeezed granite) and further on into mica-schist.

But every irregularity, whether on the large or the small scale, obstructing more or less the even motion of the layers, must create a waving or contortion in them, especially in the planes of slippery mica-plates, such as is exemplified even in hand-specimens of the Ponza trachytes, and also on the largest scale in the same locality. And the extreme irregularities of motion, occasioned on the upper layers of the intumescent mass by the pressure and resistance of the overlying beds, may be expected to carry their wavings still further, and at the throat of the fissure, where the squeeze and jam of the protruded matters must be at its maximum, to occasion those enormous and repeated zigzag foldings of the laminated beds, so frequently observed in mica and chlorite-schists in such positions.

Meantime another influence would be similarly affecting the overlying stratified rocks above, or on the outer flanks of the elevated axis, namely their own specific gravity, urging them to slide or slip laterally when tilted up at (perhaps) a considerable angle on either side. The more compact and indurated strata would be partly fractured into cliffy masses, partly broken up into breccias and conglomerates by this movement; but the softer beds, especially those which were saturated with water (perhaps even yet under the sea,) or which contained interstratified beds of silt, shale, or clay, permeated with water, would glide laterally away from the axis in extensive land-slips, and be wrinkled up into vast foldings under the intense pressure compounded of their own weight, and that perhaps of portions of the protruded matter thrust against them,—in a manner very similar to the contortions produced in the more crystalline laminated rocks by the violent squeeze which accompanied *their* protrusion. It may even be difficult to draw a line between the effects of these two replicating and fracturing forces. But, together, they seem to me sufficient to account for most of the phenomena of the kind observable in mountain chains.

These are the ideas on this subject which I endeavored to develope, though very imperfectly I am aware, in the more theoretic portion of my work on volcanos, so often referred to, and they were illustrated by a rude ideal section of an elevated

mountain chain in the frontispiece to the volume. I still think they will be found a not improbable solution of this the greatest problem in the dynamics of geology. It appears to me, that the results would be much the same, whether we suppose this elevatory action to have been *paroxysmal* and simultaneous, or gradual, taking place by minor and successive expansive throes or shocks, or even still more slowly in the manner of a *creep*, as Sir Charles Lyell would probably conceive it to have operated, and to be still continuing. On these last assumptions, the earthquake-shocks which certainly accompany at present every effort of elevation, and appear to be propagated in waves through the substance of the earth's crust, in directions usually at right angles to the principal axes of elevation, or fissures of crystalline protrusion, may indicate the force by which the extreme replications and slaty cleavage of the laminated beds are occasioned.

I would ask of geologists to consider whether such a mode of protrusion of the laminated crystalline rocks and of the lateral replication of the more earthy schists and marine strata, as is here suggested, does not accord with the general facts known respecting their position? Let me take two descriptions of the general position of the crystalline rocks from two writers of experience, judgment, and wholly impartial character, as respects the theory here indicated. Mr. Evan Hopkins* gives as the results of his extensive mining experiences in the Andes and elsewhere, "that the great base [of all mountain chains] is below more or less granitic, strongly saturated with mineral waters, and that this passes upwards by insensible gradations from a crystalline homogeneous compound into a laminated rock, such as gneiss, and still higher up into schists in vertical planes; the peculiar varieties of the higher rocks depending on the mineral character of the 'parent rock' below; the schistose rocks forming, in short, the external terminations of the great universal crystalline base,"—that is to say (as I would phrase it,) the squeezed out, and therefore laminated, upper and lateral portions of the inferior crystalline mass.

Mr. Ruskin, in his recently published volume, having closely examined the structure of the Alps with the eye of a geologist no less than of a painter, but certainly without any theory to support, declares that the central axes of "irregular crystallines" (as he calls the granitic rocks) uniformly graduate on either side into the foliated or "slaty crystallines," *i. e.*, into gneiss and ultimately mica and chlorite-schists.

One point observed in the structure of the Alps and many other mountain chains I may notice before I conclude, namely, the occasional dip of the elevated strata towards the central axis of extruded crystalline rock, producing a synclinal, instead of

* Quart. Journ. Geol. Soc., vol. xi, p. 144.

an anticlinal ridge. Another section copied loosely in the frontispiece to my work on volcanos, from Von Buch's paper on the Tyrol, may show the mode in which I conceive this to have occurred through the injection of a mass of crystalline matter into a wedge-shaped fissure, opening downwards; such as must have frequently occurred among the fractures of the overlying strata —giving occasion in some cases to the further rise of the heated and intumescent matter into the hollow between the outer slopes of the synclinal valley. It would indeed accord with the theory suggested above, if such dykes or extravasations at synclinal axes were found to alternate frequently with the elevated anticlinal axes, for the cracks formed in indurated beds of overlying rock would very frequently open alternately upwards and downwards.

Time will not allow of my dwelling now upon other points explanatory of geological problems, which are afforded by the theory of an expansive subterranean crystalline mass preserved by external pressure in a more or less solid condition beneath the crust of the globe, but always ready to expand and perhaps to intumesce upwards on any relaxation occurring in the overlying pressure. But I suggest it now, as I did thirty years since, as the solution most reconcilable with the known facts of the structure and relative position of the great elevated rock formations of the globe, and as a theory founded, not upon mere guess-work, but on careful and extended observation of the phenomena of both active and extinct volcanos, and the disposition of volcanic products of all ages.

ART. XVII.—*On the occurrence of Natro-boro-calcite with Glauber-Salt in the Gypsum of Nova Scotia;* by HENRY HAW, Professor of Chem. and Nat. Hist. King's Coll., Windsor, Nova Scotia.

THE Natro-boro-calcite, to which the following communication chiefly refers, must be ranked among the least common of minerals, inasmuch as it has hitherto been found in but one locality, and is not yet fully described in the manuals of mineralogy. The circumstances under which I have lately met with it will add not a little, I think, to the interest it already possesses, as it has been obtained in a new geological position, and in a state of greater purity than the specimens as yet examined seem to have had, so that I have been enabled to make out its true constitution which I believe, for reasons presently to be mentioned, has not till now been arrived at.

The brief history of the mineral is this. It was originally sent, a few years since, to Dr. Hayes of Boston, U. S., from Tara-

paca, in Peru, where it had been found in the nitrate of soda beds. From the analysis of this chemist it seemed to be composed of water, lime, and boracic acid, and he called it hydro-boro-calcite. Ulex, however, examined a specimen from the same locality, and finding it mixed with the nitrate and sulphate of soda, he boiled the whole with water for the extraction of these, and, analyzing the residue, he expressed his results in this formula,

$$NaO\,2BO_3+2CaO\,3BO_3+10HO,$$

and he named the mineral Natro-boro-calcite. Professor Anderson, of Glasgow, afterwards analyzed a specimen from the same locality, which, though somewhat mixed with foreign matter, he shewed to consist essentially of the mineral of Ulex. A few observations extracted from the paper containing these results,* will sufficiently mark the characters of the Peruvian mineral, and what is known of the geological nature of its till now unique locality.

"The Natro-boro-calcite is found in the nitrate of soda beds of the province of Tarapaca, in Peru, and is known to the natives by the name of Tiza. It occurs in rounded masses, varying from the size of a hazel-nut to that of an egg. Externally these have a dull and dirty appearance; but when broken across they are found to be formed of a series of interlaced needles of a brilliant white color, and silky lustre. These crystals were extremely minute in all the pieces I examined, but the specimen analyzed by Hayes was composed of prisms a quarter of an inch in length.

"The qualitative analysis indicated the presence of boracic and sulphuric acids, lime, soda, water, siliceous sand, and traces of chlorine. Ulex found also traces of nitric acid, but that which I examined contained none.

"The quantitative analysis gave results according very closely with those of Ulex, excepting that previous to his analysis he boiled the mineral with water, to extract the nitrate and sulphate of soda which he had detected, and which are obviously a mechanical admixture. This was not done in my case, as the analysis was made for commercial purposes and I was desirous of ascertaining its exact composition as it occurs. Ulex obtained:

	Expt.	Calc.
Water,	26·0	25·60
Lime,	15·7	15·93
Soda,	8·8	8·82
Boracic acid,	49·5	49·64
	100·0	100·00

which numbers agree very well with the formula,

$$NaO\,2BO_3+2CaO\,3BO_3+10HO.$$

* Proc. Phil. Soc. Glasgow, Feb. 1853.

The conditions under which this substance is found in loose masses in the nitrate of soda beds, give it a peculiar interest in a scientific point of view, and render it highly desirable that we should have full details of all the circumstances of its occurrence. The district of Tarapaca has been as yet but little explored, but it would appear that it is chiefly volcanic, and it is remarkable that up to the present moment boracic acid has never been found abundantly except in volcanic districts."

The rock in which I met with the mineral, in March last, is part of a very extensive formation of gypsum in the western centre of Nova Scotia, and the precise locality a bed of it at Windsor, on the Clifton estate, lately the property of Judge Haliburton. My attention was first drawn to the other mineral I have named at the head of this paper, the glauber-salt, as a curious 'stuff' which had attracted the notice of the quarrymen, and which they called "salts." Upon the specimens of "salts" shewn to me I at once saw that at least two distinct minerals were present, and procuring sufficient of both from the spot myself, I submitted them to examination. I give the chemical analysis in the first place, and afterwards the description of the minerals and locality.

The glauber-salt was easily separated in a pure condition, and its analysis in the fresh state gave,

Sulphate of soda,	44·54
Water,	55·46
	100·00

showing that it was the ordinary mineral,

$$NaO\,SO_3 + 10HO.$$

The second substance reminded me of the Tiza which I had seen in the hands of Dr. Anderson, in Glasgow, and a careful selection of pieces being made, it was proved by the following results to be identical with that curious mineral. The water was found by gentle ignition, the soda estimated as sulphate in a portion of the dry residue from which the boracic acid was expelled as fluorid of boron, the other ingredients in a separate quantity, the boracic acid by deficiency. The whole results were calculated upon the *air-dry* mineral, which was always employed for analysis, and I obtained from the substance as it occurred:

Soda,	8·36
Lime,	13·95
Boracic acid,	41·97
Water,	34·39
Sulphuric acid,	1·29
Magnesia,	0·04
	100·00

numbers which, notwithstanding the high percentage of water, showed me that I really had to do with natro-boro-calcite. Considering the two ingredients last mentioned as accidental, I treated a portion of selected mineral with *cold water*, washed well with the same, allowed the residue to dry in the air, and analyzed it. It was perfectly free of sulphuric acid, and gave of the other constituents,

	Experiment.	Calculation.
Soda, - -	7·21	7·82
Lime, - - -	14·20	14·12
Boracic acid, -	44·10	44·02
Water, - -	34·49	34·04
	100·00	100·00

The recurrence of the high percentage of water and the accordance of my experimental numbers, both from the purified and the actual mineral, with the calculated figures, are ample warrant, I think, for the following formula which I propose as the true expression for the air-dried natro-boro-calcite, viz:

$$NaO\,2BO_3+2CaO,\,3BO_3+15HO,$$

which differs from that of Ulex, before given, by five additional atoms of water; these, I think it extremely probable, were removed by the manipulation with boiling, and possibly by desiccation at 212°. Indeed I found that when the air-dry mineral was placed in the air-bath at this temperature, it lost, upon separate occasions,

	I.	II.	Mean.
Water =	8·25	7·58	7·91 per cent.

which deducted from my total loss, above, leaves 26·49 for the amount retained, a number so close to that really obtained by Ulex—26—as to leave me little doubt that mine is the true expression. I find also that Hayes* originally gave thirty-five per cent water as the result of his analysis.

The minerals just described were found in the closest association in narrow cavities, perhaps two inches deep, forming a kind of interrupted vein in the body of the solid gypsum-rock, exposed by blasting, about thirty feet below the surface, and extending horizontally some few feet. The more abundant mineral of the two was the glauber-salt, so far as I observed personally, but the quarry-men told me that at first the other came out in "bowlfuls," but they threw it away. I did not obtain more than a few ounces of the natro-boro-calcite, and perhaps not a pound in all was preserved by those who obtained it on this occasion.

* Liebig und Kopp's Jahresbericht, 1849, p. 780.

The glauber-salt was perfectly transparent on the first exposure, and afforded a remarkably fine instance of the crystalline forms of the mineral, some crystals which I saw partially effloresced were at least 1½ inch in length. Many masses were penetrated by perfect crystals of selenite, of various sizes, simple and in macles.

The natro-boro-calcite was along with and among the crystals of the preceding glauber-salt, and in some instances the latter seemed to be crystallized upon the former as a nucleus, or possibly they were in definite combinations as a totally distinct mineral; for crystals which at first were beautifully transparent would effloresce after a day's exposure or less, and upon being placed in water shew the silky texture peculiar to the Tiza, while plenty of sulphate of soda was to be found in the water. In other specimens, the natro-boro-calcite was alone in rounded mammillated masses in the substance of the gypsum; and these, which were of all sizes up to that of a pigeon's egg or so, on being broken, presented the appearance of a finely fibrous silky-lustrous mass brilliantly white in color.

The purest pieces had a specific gravity of 1·65; hardness =1; were tough between the teeth; tasteless; scarcely soluble in water; before the blowpipe, melted with ease to a transparent bead.

On comparing the circumstances of this occurrence with those referred to in the remarks of Professor Anderson, before quoted, and some other facts I think they are very interesting. In the gypsum of Nova Scotia we have a new and distinct locality for the rare mineral natro-boro-calcite which is analogous with that of a species chemically allied,* boracite ($MgO\ BO_3$), found in the gypsum of Holstein, and a compact boracite forming beds with rock-salt and gypsum at Stassfurth in northern Germany.

With these exceptions, boracic acid is found, as is well known, either in directly volcanic regions, most abundantly as such or as borax, and a well marked case of actual sublimation of the acid, from a volcano in the Island of Vulcano near Sicily has been studied by Warrington;† or in smaller amount in minerals the products of recent or extinct volcanoes, as Humboldtite,‡ from ejected blocks of Vesuvius and zeolites, and Datholite from trap of Salisbury Craigs, New Jersey, and other places; or in minerals of purely plutonic or metamorphic rocks, as tourmaline, the rhodizite of Rose, and axinite; the species which contain it at all being few in number. It may be noticed also that traces of this acid have lately been met with in the Kochbrunnen of Wiesbaden,§ and in the waters of Aachen.

* Nicol's Mineralogy, p. 305.
† Wells' Annual, 1856, p. 232.
‡ Nicol's Mineralogy, p. 307.
§ Liebig und Kopp's Jahresbericht, 1852, p. 328.

If we may reason from the character of the majority of its situations, we may almost consider the volcanic or at least igneous origin of boracic acid so well established as to lead us by its occurrence in the saliferous strata to seek for some volcanic agency as the cause of their production.

Such an origin has already been assigned, I find, to the gypsum of Nova Scotia by Mr. Dawson.* This formation has been shown to be a member of the Lower Carboniferous series, and is assumed to have arisen from the action of rivers of sulphuric acid more or less dilute, such as are known to exist† in various parts of the world, issuing from then active volcanoes, and flowing over the calcareous reefs and bed of the sea. "In accordance with this view the gypsum is found only in association with the marine limestone, though, as might have been anticipated, these last sometimes occur without any gypsum.‡

Gypsum, which is geologically of very various ages in different countries, was supposed by the writer just quoted, to be peculiar to the Lower Carboniferous series in Nova Scotia alone, but it has been shown by Prof. W. B. Rogers§ that a bed of this substance with rock-salt occurs in a thick deposit in limestone of the same period near New River in Virginia.

I think the occurrence of natro-boro-calcite in the gypsum of Nova Scotia cannot but lend support to the theory of Dawson as to the origin of this rock, when all the circumstances above mentioned are considered; and that a search for it or some equivalent in similar situations, might lead to more conclusive evidence as to the geological causes of the Saliferous systems in general, and furnish additional links of union between the sciences of geology and mineralogy.

ART. XVIII.—*Arctic Explorations, by Dr. Elisha K. Kane, U.S.N.*‖

THE writings and explorations of Dr. Kane are so widely known, and the volumes are so accessible to all, that a review of his works in this Journal seems hardly necessary. There are however scientific observations scattered through the volumes which it may be convenient to have here indicated if not placed in detail on record, and some results of his investigations which are profitable subjects of discussion and of wide import in science.

* Acadian Geology, p. 223.
† Lyell's Elements, Chap. xvi.
‡ Acadian Geology, p. 224.
§ Edin. New Phil. Journ., Ap. 1857, p. 360.
‖ Arctic Explorations: The First United tates Grinnell Expedition in Search of Sir John Franklin. A personal narrative, by ELISHA KENT KANE, M.D., U. S. N. 1 vol. 8vo. Philadelphia: 1857. Childs & Petersen.—The Second Grinnell Expedition, ibid., 2 vols. 8vo. 1857. Childs & Petersen.

The volume on the First Expedition is a new edition, with many additional illustrations.

Moreover we would add our inscription to the monument over the distinguished traveller. There are those who deplore so great exposure of life for the empty pursuit of geographical or scientific discovery amid the polar ice, deeming the establishment of a mere truth in science as small game compared with catching great whales and valuable seals.* It is to the credit of the race, that all are not thus narrowed down to earth and commerce. There are those that love knowledge for its own sake, and in such, mind declares its supremacy over the material, and exhibits its true exaltation. While we estimate moral triumphs above all others, we would give high honors to self-sacrifice for any great intellectual purpose, and to none more than to that of the daring navigator through polar seas. In this class Dr. Kane stands preëminent. The beneficent object also in view,—the discovery of the ill-fated ships of Sir John Franklin,—adds a still higher lustre to his name, which is shared alike by his generous patron, Henry Grinnell.

The public are greatly indebted to the enlarged views of the publishers of Dr. Kane's works, who have given them every attraction to be derived from excellent paper and typography, and a profusion of fine engravings.

In our citations from the work we shall be brief, leaving it for the reader to gather the detailed descriptions from the graphic pen of Dr. Kane himself. Moreover we shall touch only on a few of the points illustrated in the volumes, selecting especially those which have some geological bearing, and using them partly for the illustration of some topics under discussion among geologists.

Although the works may be in the hands of most of our readers, it is still desirable to give here, by way of introduction, the courses of the two cruises. The first expedition, consisting of the two vessels, Advance and Rescue, was under the command of Lieut. Edwin J. DeHaven, U. S. N., with whom Dr. Kane went out as surgeon. It sailed from New York on the 22d of May, 1850. Passing up Davis Straits and Baffin's Bay, the vessels coasted along Greenland, stopping at Disco, and continued through Melville Bay to its north cape; then crossed Baffin's Bay to Barrow Straits, and onward to Wellington Channel, near the entrance to which, the graves of some of Captain Franklin's men were found. From this place the winter drift of the vessels began; it was first to the north, up Wellington Channel to lat. 75° 25′, and lon. 93° 31′, then south (commencing Oct. 2, 1850) down this channel, and east through Barrow Straits into Baffin's Bay, to lat. 66°, lon. 58°, July 8, 1851, where they escaped from the

* Dr. Kane observes that in one year more than a thousand human beings in fishing expeditions were cast shelterless on the ice in Melville Bay, Greenland. A hecatomb has been sacrificed to trade for every Arctic explorer that has fallen.

ice which had enclosed them. The vessels after revisiting the Greenland coast, reached New York in September.

The second expedition, under Dr. Kane, left New York on the 30th of May, 1853, reached Fiskernaes, Greenland, on the 1st of July, passed up the west side of Greenland across Melville Bay, and so on north through Smith's Straits some forty miles wide at the head of this bay, into Kane's Sea its continuation sixty to eighty miles in width; and near the entrance of this sea on the Greenland side, in lat. 78° 37′, lon. 70° 40′, at Rensselaer harbor as they named it, the vessels came to winter quarters, in the latter part of August, 1853. Here they remained through the winter and a following summer and winter, making occasional excursions on foot or with sledges to the east, west, and far north. The recital of their arctic life is a tale of constant adventure and suffering, but also of successful defiance of nature's fiercest rigors; and this display of man's nobility gives a charm to the pages that are otherwise an array of dismal scenes in long gloomy succession. On May 20, 1855, the party left the vessel, and made its hazardous way over the ice and by water to the Danish settlement of Upernavik, in lat. 72° 40′, where they arrived after a journey of extraordinary perils, early in August. A Danish vessel, in September, took them to Godhavn, where they joined Capt. Hartstene, U. S. N., who had been sent to their rescue.

1. *Oceanic Currents.*—The oceanic currents, as illustrated by the Arctic cruisers, are well exhibited in a map prepared by C. A. Schott, Esq., of the U. S. Coast Survey, published with the journal of the first expedition. The grand point brought out is the general oceanic movement by all accessible channels southward from the polar sea. It is like the discharge of an over-full polar basin, sending its majestic outflows by every place of exit that offers. The waters pass down through Barrow Straits from the channels about Melville Island and from Wellington Channel, and pour themselves into Baffin's Bay, and thence down Davis Straits to the Atlantic. Another stream goes by Hudson's Straits to join the former in its southerly course, and the two unite with the great flow of cold water that comes down by eastern Greenland. These currents are not made known for the first time by the American expeditions, but their results have added to the definiteness of our knowledge on the subject. The remarkable drift of the vessels, in the first cruise, for 1000 miles, from Wellington Channel to lat. 66° and lon. 58° in Baffin's Bay, is the most remarkable current experiment that any of the world's explorers has made, and it is none the less important, that it was unplanned and involuntary.

In addition to the flows mentioned, there is also a stream descending from the far north by Baffin's Bay, through Smith's

Straits or Kane's Sea (the scene of the adventures of the second cruise), which joins that from Barrow Straits, thus making in all a descending polar flow by Eastern Greenland, Western Greenland or Smith's Straits, Wellington Channel, and one or more channels about Melville Island, besides that into the Pacific Ocean by Behring's Straits. The Behring's Straits current, though not always noticed at the surface, shows itself in the cold waters that flow by the China coast far towards the equator, making deep bends in the winter isothermal lines, and even pushing south of its normal limit the heat equator of the ocean.* It is well known that a current descending from the poles necessarily hugs the eastern coasts of lands or takes the west side of the ocean, it thus lagging westward because the motion of rotation at the poles is at a less rate than farther south. It is also understood that a flowing current will, by its own movement, draw in waters from its sides, and especially, when, as it descends a channel, the channel widens rather suddenly into a bay, and hence while the great flow in Baffin's Bay passes south along its western side, there is a counter current flowing north on the eastern side. Dr. Kane speaks of this current to the northward as made by the east Greenland current bending around south Greenland and changing to a northerly course. We should rather view it in the manner suggested, as a movement produced by the great northern current, and fed by whatever waters lie along western and southern Greenland, including of course part of those descending in the east Greenland current. In the great expedition-drift the vessels made 170 miles in the month of December, and 190 in that of May.

Writers on physical geography, as Dove and others, correctly attribute the supply of the polar seas with its superabundant waters, to the great Atlantic flow or Gulf Stream. The ocean pours north through the opening between Great Britain and Iceland, and streams out again by the various outlets which lie open before it.

The magnitude of these movements show that they belong to the organization of the earth, and as much to its geological past as its present history. They are therefore correctly appealed to by geologists in discussions of the origin of all marine strata; and especially the ancient, which are more exclusively marine. The Azoic back-bone of the continent lying just east of the line of lakes including Winnipeg and Slave lakes, and bending northeast in Canada, so as to include Hudson's Bay in its two arms,† must have always had its northern currents hugging its eastern side; and whenever the Rocky Mountains rose as a barrier

* See an isothermal chart by Prof Dana in this Journal, vol. xvi, p. 153.

† See this Journal, vol. xxii, p. 335.

against the waves, this emerged ridge would be bordered by another part of the polar current; and so also for the lower Appalachian ridge: while farther south, the warmer equatorial currents would sweep on, moving over and partly to the eastward of these colder streams, especially after passing north of 35° or 40°. The effects of the distribution of material by the agencies of these marine movements on the origin of the older formations, remain to be studied out. Their importance has been admitted but not fully appreciated.

In discussions of the phenomena of the so-called Drift-period, oceanic currents are constantly referred to by those who attribute the effect to glaciers; and the example of the glaciers that float down to the Newfoundland Banks are the usual appeal. But instruction from the north tells us, that the Newfoundland icebergs have brought their stones one or two thousand miles, and often by a very circuitous route, while those of the drift in America have traveled only twenty to two hundred miles, so that to find a parallel we must look to the shorter transfers and droppings in the far north itself, where abundant lands exist for making glaciers and icebergs. Again, the currents change with the course of the land; they are east and west in Barrow Straits, and north-northwest and south-southeast in Baffin's Bay; and moreover they have their powerful counter-currents. Consequently the position of the emerged land or coast-line of the drift period would have *then* given the course to the currents and glaciers; if this coast line were east-and-west, along by Pennsylvania and the Ohio, to the territories west of the Mississippi (the southern limit of the drift), the currents would have been nearly east-and-west, and no chance would have existed for making the north-and-south or northwest-and-southeast scratches, which are so uniform and widely distributed over the continent within the drift limits. Moreover the very uniformity of direction in the scratches and lines of stones, comes out against counter-currents, and against the fact of any bergs drifting outside of the northerly current, where they might be floated by other currents or carried irregularly by the winds, that is, they militate against the very occurrences that must have happened if the ocean had been the active agent in the drift period.

The example among Arctic currents of diversity of direction, and the still greater diversity in the courses of bergs, give the geologist little authority for concluding that in the drift period they could have been made to scratch with a nearly common course (between NW and NE) for a breadth of one or two thousand miles.

Icebergs, Glaciers.—The work of Dr. Kane abounds in views of icebergs, vivid descriptions of iceberg scenery, and accounts

of the varieties of ice and its changing conditions. He speaks of the great pack which occupies the middle area of Baffin's Bay, as if lying in the eddy between the polar current on the west side and counter current on the east; of many bergs in the bay 200 feet and upwards in height, of some "over 300 feet," an unusual altitude even in those iceberg regions; of 280 glaciers of the first magnitude within sight at one time;* of Jacob's Bight, a fiord on the Greenland coast near lat. 71° and lon. 56°, as "perhaps the most remarkable place for the genesis of icebergs on the face of the globe;"† of the immense "Humboldt glacier," in Western Greenland, which ranges on the coast from Cape Agassiz in lat. 79° 20′, to Cape Forbes beyond 80°, a distance of forty-five miles; of all northern Greenland as one continental glacier, having its many outlets along the fiords and valleys of the coast.

As to the kinds of ice-fields apart from the bergs: he describes (1) the more solid winter floe, seven feet to as many inches thick, which contains no trace of salt at surface (as shown by testing with nitrate of silver) when but two feet thick; (2) the water-sodden ice, which although supporting a person walking over it, breaks readily when struck, and displays "the vertical prisms of its crystalline structure;" (3) a honey-comb or cellular kind, "so soft that you may plunge a boat-hook into it;" (4) a granulated variety, which while "thoroughly permeated by water, is as unyielding as asphalt," and which could be punctured with a boat-hook, but would not fracture more than cork. Over the surface of the pack usually rests a mantle of snow, and here and there are pools of water, the haunts of the seal and the diver. The movements of the pack bringing parts against one another, often force up hummocks of huge uplifted masses one lying upon another, and these hummocks are at times clustered in great numbers over an ice field. Not unfrequently the great slabs of ice thus thrown up, and supported only at one end, gradually become flexed by their own weight, showing a yielding or molecular movement even in the solid glassy ice. Dr. Kane observes, "On the 20th of March, while we were imbedded in the floe with a temperature many degrees below zero, one of those great convulsions called *hummocking* had thrown up a table eight feet in thickness by twenty or more in width, and in such a position that it was sustained only at its two extremi-

* "Night before last, standing on the fast floe, I counted, between the two anchored bergs that served as framings of the picture, thirty-two icebergs in a well-marshaled group. Standing afterward on the summit of our northern buttress, I counted two hundred and eighty, the glacier terminating the eastern view. Most of these bergs were above the standard height of two hundred and fifty feet; some exceeded three hundred; few were less than one hundred."—*First Cruise*, p. 467.

† First cruise, p. 55.

ties. In the month of May, the thermometer, in the mean time, never having risen in the interval to within many degrees of the freezing point, I saw the same ice-table completely bent down, its centre depressed five feet, until arrested in its descent by a new support." These facts are referred to as proving a yielding nature in ice, even when solid instead of *half*-compacted. The bergs are described as *not* of the nature of the nevé or consolidated snow, as Prof. Forbes suggests, but as *true ice*, "having the fracture lustre, and other external characters of a nearly homogeneous growth, although they may be opaque and vesicular." He remarks that the berg is the foot of the glacier that quietly detaches itself while it lies stretching itself out in the sea, and not an avalanche that has fallen from the land.

On the disappearance of the ice-fields, we cite the following statements as bearing on the question of the disappearance of ice in Lake Champlain:—

"It was interesting to observe the compensations by which Nature got rid of this vast accumulation. The simple effects of solar heat, whether from the atmosphere above or the heated currents below, do not satisfactorily explain the dissolution of this ice. Changes in its mechanical structure evidently took place, preparing the way for the subsequent actions of thaw. My attention was first called to this fact by hearing, through my friend, Lieutenant Brown, that the observatory of Sir James Ross at Leopold Island was moist and saggy, while the outside ice remained dry and firm. In the month of May, while our mean temperature was still below the freezing point, I noticed, during my walks over the ice, that certain surface floes, which had been during the winter hard and fresh, began to yield under me as I walked, and gave a decidedly brackish taste to the palate. The ice, too, in many cases lost its tenacity and resistance. Our coal, which had been thrown out loosely on it, so depressed the little area around it, as to be surrounded by water; and some of the larger hummocks, whose colossal blocks had attracted my attention during the winter, were now wet and marshy to approach. Upon excavating blocks of ice with the saw and pickaxe, it was found, in many cases, to have lost its well-condensed character. It was divided by vertical lines into prisms, which stood prominently out, and ran continuously from the watery to the atmospheric surface, with an arrangement almost basaltic.*

"Struck by this circumstance, I was led to test the ice of different localities by both the Marcet's bottle and the nitrate of silver, and discovered that the floes, which had formed in midwinter at temperatures below −30, were still fresh and pure, while the floes of slower growth, or of the early and late portions of the season, were distinctly saline. Indeed, ice which only two months before I had eaten with pleasure, was now so salt that the very snow which covered it was no longer drinkable.

* "I am happy to find since my return, that this basaltic arrangement of the ice has been noticed by Sir John Richardson."

"This is a subject well worthy of future examination. The dissolution of the great ice-fields of the Polar regions bears upon physical questions of the highest importance; and it really seems to me that changes, independent of expansion and contraction, must take place in the molecular condition of the ice at temperatures greatly below the freezing point."—*First Cruise*, pp. 391–392.

Dr. Kane also alludes to an action like endosmosis from the pools of fresh water above and salt water below, as probably having some effect. But if so, it would be confined to the salt seas. The basaltic character of the ice, and its becoming permeated with water and breaking up into prisms, has been noticed on Lake Champlain by Dr. Hatch of Burlington, Vermont. The swell of the ocean is an important agent in the final destruction of the floe in the polar regions, and a storm gives it great power.

In the gradual wasting of some bergs, they became covered with circular depressions a foot in diameter; and one tall and slender one was so strikingly spotted in this way that Dr. Kane gave it the name of the Giraffe. No sufficient reason for the peculiarity is mentioned.

We cite a few sentences on the rolling over of a berg and some of their movements:—

"Nothing can be more imposing than the rotation of a berg. I have often watched one, rocking its earth-stained sides in steadily-deepening curves, as if to gather energy for some desperate gymnastic feat; and then turning itself slowly over in a monster somerset, and vibrating as its head rose into the new element, like a leviathan shaking the water from its crest. It was impossible not to have suggestions thrust upon me of their agency in modifying the geological disposition of the earth's surface."—p. 455.

"The berg is beyond all doubt a most important agent in modifying the soundings upon the coast. The grounded bergs off Disco are known to leave troughs, plowed by their projecting tongues, as they float and ground with the rise and fall of the tides. Where the bottom is of mud and till, as is the case on the west coast generally, this action must be very marked; for on a berg I surveyed trigonometrically in July, which had grounded in soundings of five hundred and twenty feet, the great tap-root that anchored it to the bottom admitted of an easy rotation, and the berg swung upon its axis with each change of the tide.—p. 458.

Arctic turf.—The following description of the turf found in Arctic regions has interest to the geologist, and we therefore cite it, although published in the earlier work of Dr. Kane. Speaking of a small cove near lat. 76°, the author thus writes:—

"Strange as it seemed, on the immediate level of snow and ice, the constant infiltrations, aided by solar reverberation, had made an Arctic garden-spot. The surface of the moss, owing, probably, to the extreme alternations of heat and cold, was divided into regular hexagons and other polyhedral figures, and scattered over these, nestling between the

tufts, and forming little groups on their southern faces, was a quiet, unobtrusive community of Alpine flowering plants. The weakness of individual growth allowed no ambitious species to overpower its neighbor, so that many families were crowded together in a rich flower-bed. In a little space that I could cover with my peajacket, the veined leaves of the Pyrola were peeping out among chickweeds and saxifrages, the sorrel and Ranunculus. I even found a poor gentian, stunted and reduced, but still, like every thing around it, in all the perfection of miniature proportions.

"As this mossy parterre approached the rocky walls that hemmed it in, tussocks of sedges and coarse grass began to show themselves, mixed with heaths and birches; and still further on, at the margin of the horseshoe, and fringing its union with the stupendous piles of debris, came an annulus of Arctic shrubs and trees.

"Shrubs aad trees! the words recall a smile, for they only typed those natives of another zone. The poor things had lost their uprightness, and learned to escape the elements by trailing along the rocks. Few rose above my shoes, and none above my ankles; yet shady alleys and heaven-pointing avenues could not be more impressive examples of creative adaptation. Here I saw the bleaberry (*Vaccinium uliginosum*) in flower and in fruit—I could cover it with a wine-glass; the wild honey-suckle (*Azalea procumbens*) of our Pennsylvania woods—I could stick the entire plant in my button-hole; the *Andromeda tetragona*, like a green marabou feather.

"Strangest among these transformations came the willows. One, the *Salix herbacea*, hardly larger than a trefoil clover; another, the *S. glauca*, [S. Uva-ursi], like a young althea, just bursting from its seed. A third, the *S. lanata* [S. arctica], a triton among these boreal minnows, looked like an unfortunate garter-snake, bound here and there by claw-like radicles, which, unable to penetrate the inhospitable soil, had spread themselves out upon the surface—traps for the broken lichens and fostering moss which formed its scanty mould.

"I had several opportunities, while taking sextant elevations of the headlands, to measure the moss beds of this cove, both by sections where streams from the lake had left denuded faces, and by piercing through them with a pointed staff. These mosses formed an investing mould, built up layer upon layer, until it had attained a mean depth of five feet. At one place, near the sea line, it was seven feet; and even here the slow processes of Arctic decomposition had not entirely destroyed the delicate radicles and stems. The fronds of the pioneering lichens were still recognizable, entangled among the rest.

"Yet these little layers represented in their diminutive stratification, the deposits of vegetable periods. I counted sixty-eight in the greatest section.* Those chemical processes by which nature converts our autumnal leaves into pabulum for future growths work slowly here."—*First Cruise*, pp. 142, 143, 144.

* "I copy the number of these layers as I find it marked in my journal; yet I do so, not without some fear that I may be misled by the chirography of a very hurried note. My recollections are of a very large number, yet not so large as that which my respect for the *littera scripta* induces me to retain in the text."

The Polar Sea.—The "open polar sea" is the grand discovery announced by Dr. Kane that has excited most attention. What was a mere matter of speculation has passed into the sober narration of a cautious and credible Arctic voyager. Yet all naturally receive the conclusion with a grain or more of doubt. It is against old notions; and moreover it is urged with reason, that the sea was not seen by Dr. Kane himself but by two of his men; that the whole extent of clear water claimed is but sixty miles square (4000 miles), and that the mirage of those northern regions, which in Dr. Kane's experience played such pranks again and again with the mountains and ice, and exaggerated or diminished distances beyond the power of reason to correct or allow for, might have led to an over-estimate of the extent of open water discovered.

The excursion to the north, from the vessel at Rensselaer Bay, was undertaken in June of 1854, after they had already been ten months ice-bound. The party consisted of two men by the names of Morton and Hans, the latter an Esquimaux, Dr. Kane at the time being too much disabled to join them. Fifteen or twenty miles north of the parallel of 80°, the water called Kane's Sea narrows to forty or fifty miles, and here it has been named Kennedy's Channel. Near the entrance to this channel, about two degrees north of the vessel, they found open water, the temperature of which was 36° F., with no solid ice beyond.* Morton continued up Kennedy Straits with his companion, and finally reached the parallel of 81° 20′, on the Greenland side, where he was stopped by a bold cape. Here, from a height of 480 feet, commanding a horizon of "almost forty miles," "his ears were gladdened with the novel music of dashing waves, and a surf breaking in among the rocks at his feet." About the ship no birds of the returning season had been seen. But here on the borders of the open sea, "the Brent goose (*Anas bernicla*), the eider and the king duck, were so crowded together that our Esquimaux killed two at a shot with a single rifle-ball. The Brent goose had not been seen before since entering Smith's Straits." The rocks were crowded too with swallows. There were also four species of gulls; and at the farthest point, Morton saw the Arctic petrel (*Procellaria glacialis*) "flitting and hovering over the crests of the waves," a bird which was last seen, when the vessel was on its way north the preceding season, 200 miles south of where they then were; and as it feeds on the life of the waters, it is one that requires an open sea.

* Dr. Kane states, that in latitude 78° 50′, near Rensselaer harbor, when the temperature at the surface of the ice-floes was −30° F., it was −8° at a depth of two feet in the ice, +2° at four feet, and +26° at eight feet. The freezing point of sea-water at Rensselaer harbor was 31° F.

The coast of Greenland at the point reached (named Cape Constitution) appeared to trend off to the eastward, while on the opposite side, the shore of Grinnell land stretched on to the east of north as far as the eye could reach, the farthest point seen being put down in lat. 82° 30′, and long. 66°. This point is within 450 miles of the pole. The mountain heights on this (the western) side varied from 1500 to 2500 feet, while farther south, opposite Rensselaer harbor, they were 1200 to 2000 feet.

Such is the account and such the nature of the evidence which the distinguished navigator has furnished respecting the open polar sea. Taking the facts as narrated, supposing no error from refraction or otherwise, it is reasonable to infer from the existence of so large a body of clear water its connection with a much larger one, since the circumstances of intense cold that would cover the waters around with ice, would not leave a spot of so limited extent uncovered except as a temporary condition; and the birds and abundant life sustain the conclusion that it was no unnatural event, for, in their migrations with the seasons, they are always regarded as good thermometric indicators. But admitting that the open sea exists, the trend of the Grinnell land to the east of north, leaves it uncertain in what latitude —whether on the American side of the position of the pole, or the opposite, or both,—the waters stretch off westward, which make up the so-called Polar Sea. The *open* sea may lie wholly on the Atlantic side of the pole, as far as the account fixes its position.

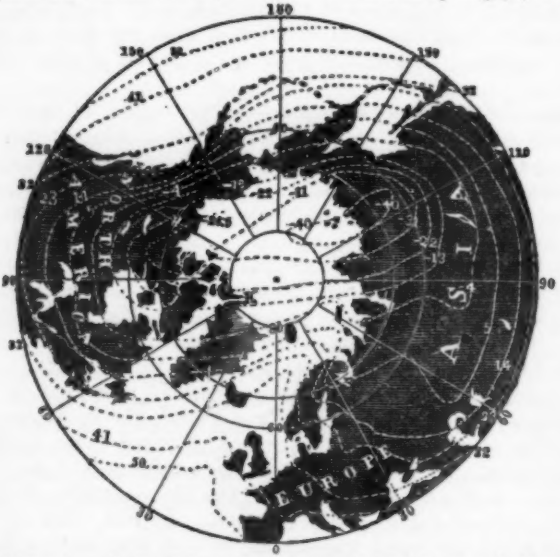
Under the doubts which necessarily rest upon a single investigation of such a question at but one point of time in one single year, most persons will allow their opinions to be swayed by general considerations apart from the narrated observations. We offer a few thoughts on the subject without attempting to give it a full discussion.

The fact that the cold of the globe is dependent on the distribution of the land, so well illustrated by Lyell in his geology, has an important bearing on the question. The immobile land, buried in snows over the north is a fixed repository of cold, while the mobile waters are modified by currents. Consequently, if the Polar Sea is an archipelago like that of northern North America, it is hardly a possibility that the waters should be clear of ice; we may say positively that they could not be open. The frozen icy lands would ensure an intense cold, and a frozen sea between. On the contrary, if the sea is without land for a radius of twenty degrees, that is, within the circle of 80°, and the whole is one area of ocean, 1200 miles in diameter, we cannot assert, on the ground of the facts in Arctic America, that this great body of water would be frozen over. The free ingress of the Atlantic gulf stream along

by Spitzbergen (well shown by Dove's charts), and the free passage it would then have across to Behrings Straits, would obviously make so ready an interchange of temperature that we might well hesitate before pronouncing that the polar ocean would be an icy one.* It would have half the breadth of the Atlantic and make a large body of water to cover with ice. In addition, we have to consider that besides the source of heat from the Atlantic, the ocean, even within the Arctic circle, has at some depth, not very great, a temperature of 40° F.; for an isothermal plane of 40° bends around the globe within the ocean, from pole to pole, and no temperature colder than this exists below it, this being the maximum cold found by sounding in the tropics, and a temperature reached at some greater or less depth in the polar regions. Now as this substratum temperature is due to the pressure and the waters above are correspondingly affected, this cause must have some influence over the power of the cold of the atmosphere to freeze deeply the waters.

We may therefore safely conclude that so vast a polar ocean, if unencumbered by land, would be to a great extent a clear sea.

* We repeat in this place a woodcut copied from one of Dove's charts (in his Verbreitung der Wärme, &c., 1852) reduced one-half in diameter. It gives an idea of the position of the isothermals; and we have added the opening (K) at the head



of Baffin's Bay towards the Polar regions, along which Dr. Kane made his explorations. The temperature in Fahrenheit degrees (the *mean January* temperature) is given upon each of the lines, the difference between any two adjoining being 9° Part of the known lands north of North America are not represented. See also, in connection, the isothermal chart in volume xv of this Journal.

In this connection we may add farther, that were the globe without land, a universal ocean, it would probably be without ice even in its Arctic and Antarctic seas. Its mean temperature might be little different from the present, or near 58° F., but its range would be small compared to what it is under existing circumstances.

But have we any good grounds for supposing that the polar sea is unencumbered by land? Here is the embarrassing point in the hypothesis. We have seen that the narrative of Dr. Kane, allowing the facts stated all the weight they can demand, only suggest that the part of the polar circle between the pole and the coasts of Greenland and Nova Zembla may be open or unfrozen; and this is the part in which the sources of heat mentioned would act most decisively, being that into which the Gulf Stream flows. Greenland may stretch eastward towards a point north of Spitzbergen and so be the occasion of ice where Parry made his sledge excursion; while a little more to the east beyond this the ocean may have its free play northward. The oceanic isothermal lines laid down by Dove on his charts correspond with this idea, for the warmest part of the arctic circle is the half which is north of Spitzbergen; moreover, the long loops or flexures in the isothermals stretch up in winter northeast between Nova Zembla and Spitzbergen, with no bend up between Spitzbergen and Greenland; as if the former were the free direction for the waters. This course along the north Asiatic coast is mainly due, beyond doubt, to the eastern tendency in the waters; but yet we might expect an expansion to the northward by Spitzbergen if, there, lay the open channel pole-ward. Again the degree of cold for any place in America depends mostly upon the amount of land to the northwest of it. Now we find that in the coldest months, February and March, taking as data the deductions made by Mr. C. A. Schott from Dr. Kane's and other Arctic observations, the meridian of greatest cold is near the meridian 85° or just west of the head of Baffin's Bay, where Mr. Schott's chart gives −41 as the mean temperature for March. Now were the region that lies to the north and northwest of this, an open sea, it would be incredible that so low a temperature should exist along this meridian; but if an archipelago, or if there is at least a moderate proportion of land towards the poles, it then would be just that vast ice-house that in connection with the great continent of Greenland would aid in locating the point or meridian of extreme cold for America where it is actually found. Mr. Schott remarks on this point, that the extreme cold of Rensselaer Bay and Wostenholm, "point most conclusively to either a considerable northern expanse of Grinnell Land on one side and an eastern extension of Washington Land (northern Greenland) on the other, or to a

considerable elevation of the interior on both sides of the channel above its level."

It appears from the records kept, that the winds at Rensselaer harbor for January, February and March were mostly from between south and east. But in the former cruise, the observations in Baffin's Bay for the same month were generally between north and west; and as these were registered at sea remote from the land, they may give most correctly the prevailing atmospheric movement in winter for that region of the globe. North and northwest winds were found to be the most prevalent in the same months by Parry and Ross.

A review of the general considerations bearing on the temperature of the arctic regions, incline us therefore to believe in an open sea—comparatively open at least in some years—in the part of the polar circle towards Spitzbergen or Nova Zembla, the part to which the narrative of Dr. Kane relates. But we doubt strongly whether the other half is free from land or ice; and certainly there must be ice, if there is much land within it, or, in other words, if it is an archipelago.

The rocks, of the coast between Rensselaer harbor and the great Humboldt glacier, were stratified limestone, red sandstone, feldspathic and often porphyritic granite, passing into gneiss, and in some places trap. The limestone and sandstone formed lofty cliffs, averaging 900 feet in height. Hakluyt Island in latitude 77° 20′, presents on the coast a coarse red sandstone in nearly horizontal strata, while in the back country the rocks were in broken pyramidal shapes, appearing to be "greenstone."

The peaks of Greenland from the south cape to Disco, in latitude 70°, vary in height from 800 to 3200 feet; those of Pröven, latitude 71°, 2300; and those in lat. 76° 10′, 1380 to 1800 feet.

A large trap-dyke is described as intersecting the island of Disco, in latitude 70°, in an east-northeast direction, and crossing the channel of Waigat, separating it from the main land; and Dr. Kane speaks of its parallelism with the trap of Lake Superior. The other rocks of the region are syenitic gneiss, argillaceous and chloritic slates, with trap and amygdaloid. The dip of the slates at one point was 25° to the northeast.

The volumes of Dr. Kane also contain tables of meteorological observations, and of magnetic dip and intensity; notices of auroras; a plate of maps by C. A. Schott, giving the isothermal lines for the arctic regions north of America for each month of the year; a list of plants collected by Dr. Kane on the coast of Greenland and remarks, by Elias Durand; besides tables of geographical positions. His statements respecting the freezing of different substances by the extreme cold he encountered are of

much interest, but he intimates that a complete report on the subject and also on other points of science, including the geology, will appear elsewhere, and we trust that it may yet be published from his papers.

The wide discrepancies ascertained in his spirit thermoneters at very low temperatures may be considered an observation of interest, as they will lead to precautions in future in the construction of such instruments. We close by a citation on this subject from the Appendix, 2d Expedition, pp. 405, 406, and also a table of temperatures, p. 425.

"Except in naval expeditions, Arctic temperatures, whether Asiatic or American, have been recorded with a limited number of instruments. The results of these must be received with extreme caution; for the differences which alcoholic thermometers exhibit at temperatures below the freezing point of mercury are so varying as to require a large number of comparisons and upon many instruments, to determine their proper correction. It was not uncommon for thermometers, which had given us correct and agreeing temperatures as low as $-40°$, to show at $-60°$ differences of from fifteen to twenty degrees. Such too was the case with the well-constructed instruments of Sir James Ross at Leopold Harbor.

"To give an example of this, I may refer to the record of six thermometers, suspended near each other as above described, and observed for purposes of comparison at noon, February 5, 1854, $-71°$, $-63°$, $-54°$, $-53°$, $-50°$ and $-50°$. All of these at temperatures above $-40°$ agreed within $1{\cdot}8°$, and were selected as the most consistent of nearly thirty spirit thermometers.

"At 9 A. M. of the same day, eleven similar thermometers, gave under like circumstances, a mean of 68°, the extreme readings being $-56{\cdot}4°$ and $-80°$. For the purpose of obtaining the most probable temperature from these conflicting records, my first impulse was to reject the lowest (coldest) extremes, and take the mean of those which accorded best; but upon advising with our astronomer, Mr. Sontag, I determined to take the mean of all, without rejecting any,—the view which he took being simply that those instruments which indicated the extremes in the low scale had never in temperatures above $-40°$ shown any anomaly which deprived them of an equal claim to confidence with the rest, and that there was no reason *a priori* to consider the results which they gave as less probable than those shown by the others. * * * *

"Our thermometers were made with great care by Taliabue, of New York. But, independently of other mechanical sources of error, I am obliged to say that I do not regard the contraction of colored alcohol at very low temperatures as sufficiently investigated to enable us to arrive at the causes or the quantity of error. In most of the spirit thermometers the uniform thickness of the tube was tested before leaving New York; and the freezing of carefully-distilled mercury which I had taken with me for the purpose, gave excellent determinations of absolute temperature.

"But it may not be uninteresting to state that the freezing-point of this metal varied between $-38{\cdot}5°$ and $-41{\cdot}5°$, and that its rate of contraction as a solid was so uniform, that in our long and excellent 36-inch

standards it descended after freezing as low as −44°. This result is in accordance with that obtained by Sir Edward Belcher, whose experiments go even further than my own,—the mercury having been observed by him to descend as low as 46° below zero."—*Second Expedition*, pp. 405, 406.

Synopsis of mean monthly readings of atmospheric temperature and pressure, and of observed maxima and minima temperatures.

Date.	Temperature of Air.			Barometer.	Attached Thermometer.
	Mean.	Maximum.	Minimum.		
	°	°	°	Inch.	°
1853, June, ...	+48·63	+70·0	+35·0	29·890	+55·73
July	+37·83	+51·0	+30·0	29·727	68·83
August.....	+33·41	+46·0	+25·0	29·661	68·92
September....	+17·16	+32·0	− 2·2	29·678	55·86
October	+ 0·55	+17·8	−23·7	29·801	69·76
November	−23·01	+ 0·2	−43·2	29·726	34·35
December	−25·99	+15·8	−45·7	29·842	36·36
1854, January	−30·24	+11·0	−59·9	29·461	29·66
February	−33·60	−11·3	−68·0	29·642	24·69
March.....	−38·09	+ 0·9	−55·6	29·760	14·52
April	− 8·60	+14·3	−43·0	29·981	29·71
May	+12·89	+39·4	− 8·7	29·970	51·62
June	+29·23	+41·9	+17·7	29·780	53·98
July	+38·40	+53·9	+27·6	29·784	46·67
August.....	+31·35	+48·9	+19·1	29·711	37·66
September....	+ 9·81	+26·6	− 8·9	29·682	41·22
October	−10·54	+22·9	−41·0	29·743	51·60
November	−23·03	+ 4·3	−49·9	29·855	51·98
December	−37·74	− 8·4	−61·4	29·728	49·98
1855, January	−28·61	+25·2	−69·3	30·141	49·31
February	−21·21	+19·6	−53·9	30·095	51·88
March.....	−33·97	+ 2·3	−56·1	29·795	67·17
April	−14·00	+ 8·9	−42·3	29·904	59·93
Autumn, (1853)	− 1·77	+32·0	−43·2	29·735	53·32
Winter, (1853–54)...	−29·94	+15·8	−68·0	29·648	30·24
Spring, (1854).....	−11·27	+39·4	−55·6	29·904	31·95
Summer, (1854), ...	+32·99	+53·9	+17·7	29·758	46·10
Autumn, (1854)	− 7·92	+26·6	−49·9	29·760	48·27
Winter, (1854–55)...	−29·19	+25·2	−69·3	29·988	50·39

Difference, (Summer and Winter,)	62·93°
" warmest and coldest m'nth,	76·49
" maximum and minimum,	123·20

Mean of the year 1854.

Temp. of Air.	Barometer.	Attached Therm.
−5·01°	29·7581 inch.	+40·27°

The maximum of temperature was +53·9°, and occurred on the 4th of July, 1854. The minimum in 1854 was −68·0°, and occurred on the 5th of February. In 1855 it was −69·3° on the 7th of January.

From September, 1853, to April, 1855, (inclusive,) the observations were made at nearly the same place; hence the means of the same months in 1353, 1854, and 1855, would be combined for the mean annual temperature and the mean annual height of barometer given in the following table.

Lat. 78° 37′ N., lon. 70° 40′ W. from Greenwich.

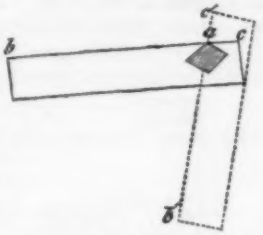
Month.	Mean temperature of air.	Barometer.	Attached Thermometer.
	°	inch.	°
January	− 29·42	29·801	+ 39·48
February	− 27·40	29·868	38·29
March	− 36·03	28·777	40·84
April	− 11·30	29·942	44·82
May	+ 12·89	29·970	51·62
June	+ 29·23	29·780	53·98
July	+ 38·40	29·784	46·67
August	+ 31·35	29·711	37·66
September	+ 13·48	29·680	48·54
October	− 5·00	29·772	60·68
November	− 23·02	29·790	43·16
December	− 31·86	29·785	43·17
Year	− 3·22	29·805	+ 45·74
Spring	− 11·48	29·896	45·76
Autumn	− 4·85	29·747	50·79
Summer	+ 32·99	29·758	46·10
Winter	− 29·56	29·818	40·31

"The preceding tables show that the mean temperature of the year 1854 was 1·79° colder than the mean temperature of the year as derived from twenty months' observations."—p. 425.

The scientific facts which have been cited from the volumes of Dr. Kane, are but a selection of comparatively dry detail from a work full of incidents in illustration of the topics we have discussed. And whatever the subject, whether icebergs, glaciers, or stormy seas, Esquimaux, walruses, or polar bears, or their own personal life when frigid night settled about the camp, or when they sallied forth to battle with stern nature and raise the standard of victory over her frowning heights, the varied scenes stand out in all their reality before the reader of his stirring words. Although the hero of the Arctic has since fallen by disease, his triumph was complete; and in his death, it was followed, as we may trust, by another more glorious triumph above all the clouds and cold and darkness of earth. J. D. D.

ART. XIX.—*A method of measuring the Angles of Crystals by reflection without the use of a Goniometer;* by P. CASAMAJOR.

THE method of measuring the angles of crystals by reflection, is well known to be the most accurate that has been proposed. But goniometers by reflection are costly instruments and, besides, not always at hand. For these reasons I have devised the following as a substitute; and I here announce it, believing that it will prove useful to travelling mineralogists who have not goniometers with them, and to students who do not wish to incur the expense of buying an instrument.



To measure the angle of inclination of two faces of a crystal, I use a rule bc with a straight edge. On one end the crystal is placed on a piece of wax. The eye is then brought near to the crystal until a clear vertical line is seen, such as a vertical bar of a window. The crystal is then moved on the wax until the image reflected be also vertical. The same is then done with the other face, and when the reflection of the bar is vertical on both faces, the crystal is adjusted, which is done after a few trials. The rule is then placed on a sheet of white paper, which is placed on the edge of a table. The paper must not be moved during the operation. The eye is again placed near one face of the crystal which is turned until the reflected image is made to coincide with some other vertical line seen directly. Then a pencil is passed along the straight edge and a line made on the paper. Under the edge of the crystal a mark is made to fix the point that is to be the vertex of the angle. The rule is then turned until the reflected line on the other face and the line seen directly coincide. In this second position, the vertical edge of the crystal must be again over the mark made under it in the first position. This is to oblige the eye to place itself in the same position that it had at first. A line is then drawn along the edge and the angle of these two lines is the supplement of the angle between the two faces of the crystal. This needs no proving as the principle is the same as in the case of Wollaston's goniometer.

The angle on the paper can be measured by a protractor, or in any other convenient way.

If the operator has no protractor but has a table of natural or logarithmic cosines, the best way is to make a triangle and to measure its three sides. Calling A the angle measured by the two lines, a the sides opposite to it, b and c the adjacent sides. Then $a^2=b^2+c^2-2bc\cos A$. When the angle A is acute the cosine is positive; when it is obtuse the cosine is negative. If we take $b=c$, we have

$$a^2=2b^2-2b^2\cos A$$

and if $b=1$

$$a^2=2-2\cos A.$$

Then when the angle is acute,

$$\cos A=\tfrac{1}{2}(2-a^2)=1-\tfrac{1}{2}a^2,$$

and when the angle is obtuse,

$$\cos A=\tfrac{1}{2}a^2-1.$$

Example: a crystal of Iceland Spar gave an angle by the two positions of the rule. Each side adjacent is made 1 decimeter long. The side opposite measured 1·215 decimeter, the square of which is 1·47622, whose half is 0·73811

$$\cos A = 1 - 0{\cdot}73811 = 0{\cdot}26189.$$

The angle corresponding to this cosine is 74° 50′; the supplement is

$$180° - 74°\,50' = 105°\,10'.$$

Although any rule with a straight edge will answer the purpose, a metallic rule is to be preferred, because its weight makes it more steady. Instead of a sheet of paper the top of a white marble mantle-piece may be used. It has the advantage of being immovable, and pencil marks on it are easily erased.

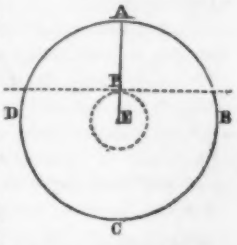
Many ways might be proposed for adjusting the crystal. I stick wax on the ruler and adjust the crystal with the hand. Wax adheres well to brass, ivory and steel, not so well to wood.

The measurement by a rule is not proposed as better than by a goniometer; but when the operator has not a good instrument, he will find it a simple and accurate method. An angle can be read to within 15′ with a good protractor of 1 decimeter radius, or by measuring the side opposite to the angle A and calculating cos A.

ART. XX.—*Explanation of the Motion of the Gyroscope;* by H. A. NEWTON.

THE instrument called a *gyroscope*, as made in this country, is a heavy wheel suspended in a ring. The wheel can revolve on its axis in the ring, and the whole can move in any way about a fixed point in this axis. The instrument differs from Foucault's gyroscope in that its center of gravity and the fixed point do not coincide. In what follows, the ring and the effect of friction are disregarded.

Let A B C D be a section of the wheel through its center of gravity E, and perpendicular to its axis. Designate by O the point of support, O E will be the axis of the wheel.



If from a state of rest (OE not being vertical), the wheel is left to the action of gravity, it will vibrate back and forth like a pendulum. But when a rapid rotation is given to the wheel, and it is then left to the action of gravity, we find that it no longer swings like a pendulum, but O E commences a slow revolution about a vertical line through O. The direction of this motion is the same as

that of the lower side of the wheel. The line O E thus describes a conical surface.

The case in which this conical surface is that of a right cone, and is described by a uniform velocity of O E, is the only one I shall consider. It is proposed to show, that if such a motion is produced by a force applied at E, that force must be constant, and in the vertical plane P O E.

For this purpose let the motion in question be considered as generated in a different way. About E as a center, with some radius P E, describe a circle in the plane A B C D. Through P the highest point of this circle let a horizontal plane be drawn cutting a vertical line through O in Z, join P Z. About Z as a center describe in this plane a circle with P Z as radius. The first of these two circles is in the wheel and moves with it. The second is fixed in space. If the circumference of the first rolls on that of the second, O E will describe a right cone.

Now by varying the ratio P E : P Z, we can vary at pleasure the ratio of the velocity of rotation of the wheel about its axis to that of the plane P O E about O Z. Any motion, therefore, like that we have to consider, may be generated by the rolling of one circle upon another.

The point of contact P of the two circles is always in the same vertical plane with O E. This point is *for the instant* at rest, and the body may therefore be considered as revolving about O P.

By this rotation the center of gravity E would describe a circle about P, if neither *centrifugal forces arising from rotation*,* nor foreign forces acted on the body. The force at E must be such as will change this circular into a horizontal motion.

This must be a downward force. For, the instant after O P is at rest P moves downward, and to produce this motion a force in the plane P O E is necessary. It must also be constant. For, the circle which E tends to describe is always of the same radius.

Now besides foreign forces we must consider the centrifugal forces arising from the rotation. The resultant of these must be in the plane P O E, since the body is symmetrical with respect to that plane, and revolves about an axis in it. It is constant, for the circumstances under which it is produced are ever the same. It may be downward or upward. In either case, the foreign force to be applied at E, being the sum or difference of two constant forces, is itself constant. It must evidently be in the plane of the other two, that is, in the vertical plane P O E.

It requires then a constant downward force at E to produce a uniform horizontal motion of the center of gravity.

* The meaning of this phrase may be explained by an example. When a wheel revolves on an axis inclined to its plane, the rotation produces a tendency to increase the angle of inclination. The causes of this tendency are the so-called *centrifugal forces*. They are treated as *forces*, because, in the motion of a free body an opposing *force* must be applied, if the axis of rotation is to remain unchanged.

This investigation supposes the motion of E horizontal. This is not usually the case. With a given rotation about a given axis O P in the vertical plane through O E, we have seen that there is needed a certain determinate force at E to produce horizontal motion. Conversely then, for a given force at E, as gravity, and a given initial rotation about O E a determinate horizontal impulse must be given to E, that is a determinate line O P in the plane P O E must be at rest the first instant, if horizontal motion is to be produced.

With any other initial impulse the motion is much complicated. The resultant of the centrifugal forces is no longer in the vertical plane P O E. Its direction is constantly varying. The determination of the motion in this general case I do not propose to undertake. My object has been to show in the simplest case, and by methods not involving the processes of analysis, the action of a vertical force producing horizontal motion of the center of gravity.

ART. XXI.—*Correspondence of M. Jerome Nicklès, dated Paris March 7, 1857.*

Academy of Sciences. Distribution of Prizes.—Conformably to usage, at the annual meeting of the Academy opening the new year, a eulogy was pronounced by the Perpetual Secretary on one of the former members; and this year, the subject was the mathematician Coriolis, who died September 18, 1843. His titles to this honor and the remembrance of posterity are of more than one kind. He contributed largely to the progress of applied mechanics, by presenting in a new light the subject of *living forces;* in defining precisely what should be understood by *the work of a machine;* in being the first to substitute for the consideration of bodies taken in mass, the consideration of them as composed of distinct molecules.

Prizes were distributed by the Academy for different questions that had been previously proposed, the more important of which we mention, premising that the subjects were open to the scientific men of all countries.

The great prize for mathematical science was given to a German, M. Kummer, for his Researches on complex numbers consisting of roots of unity and of whole numbers. One of the grand prizes in physical science was given to Professor Bronn at Heidelberg, for an extensive work made in reply to the following questions:—1. What are the laws of distribution of fossil organized bodies in the different sedimentary strata as regards their order of superposition; 2. What as to their successive or simultaneous appearance or disappearance; 3. What the rela-

tions which exist between the present condition of the organic kingdoms and that of earlier time.

Another prize, which had been held out ever since 1847, was given to Lereboullet, Professor of Zoology at Strasbourg. The subject was the following: *To establish, by studying the development of the embryo in two species, taken one from among the Vertebrata, and the other either from the Mollusca or Articulata, the basis for comparative embryology.* It was a question requiring long investigation, and was treated by Lereboullet in his usual thorough style. The Academy awarded him a medal of gold, valued at 3000 francs.

The prize in Experimental Physiology was divided between Messrs. Waller, Davaine and Fabre; the first, for his experiments *on the ganglions of the rachidian nerves;* the second, for his experiments *on the Anguillula Tritici;* the third, for *researches on the action of the poison of the Cerceris* (*Hymenopterous insects*) *on the nervous ganglionary system of insects.* This is not the place to analyze the interesting researches of these physiologists. But we may say however that M. Fabre brought out the fact that the larves, with which the insects of the Cerceris family provision their nests for the nourishment of their own young, are struck with a kind of paralysis, which permits of their living for a long time while depriving them of the faculty of feeling or moving. This species of anesthetic condition is produced by the puncture of one of the thoracic ganglions by the sting of the Cerceris; and M. Fabre has succeeded in producing this condition at will by introducing a little ammonia into the nervous ganglionary system, an effect which he has repeated in other insects.

With reference to the expenses of carrying on these researches, the Academy contributed a certain sum to each, and also divided between them the prize of 5000 francs.

As usual, the Academy found nothing to compensate or encourage in physics, chemistry, or in mineralogy, if we except a prize of 2500 francs given to M. Schroetter for the discovery of the isomeric state of red phosphorus. It was decreed by the Commission for the prizes relative to the insalubrious arts, for the year 1856, a Commission consisting of MM. Rayer, Dumas, Pelouze, Boussingault, Combes and Chevreul. We say it, to the honor of this Commission, that the prize was declared not solely for the discovery of a non-poisonous phosphorus which could be employed in preparing matches in place of ordinary phosphorus, but also in addition to this, because of the scientific merit of the discovery.

This same Commission decreed 2500 francs to a workman named Chaumont, the inventor of a machine for separating the long hairs of the skin of the rabbit from the short and fine hairs which are exclusively used in making the felt of hats. In France, this operation is called "éjarrage," because the long

hairs are called "jarres" by tanners. The work had been done by hand, and was very injurious to health, as the workmen were exposed to breathing an atmosphere charged with particles of hair; and this evil is mostly removed by the new invention, while at the same time the method is more economical, as each machine, directed by a single workman, does the work of six females.

The commission on prizes in medicine has given delight to many; more than 50,000 francs were distributed by them to reward discoveries or useful applications in the healing art. Among the laureates, there are

Dr. *Simpson* of Edinburgh, who, as stated by Mr. Flourens, first introduced chloroform into anesthesis for surgical operations.

Dr. *Middeldorp* of Vienna (Austria) for the application of the galvano-caustic in certain surgical operations, to which we alluded in our letter published in the number of the American Journal for November, 1856.

Mr. *Brown-Sequard*, for having shown that various lesions of the spinal marrow in the Mammalia, may be followed after some weeks by a convulsive epileptiform affection, produced either spontaneously or by excitation of the ramifications of the fifth pair of nerves on the side corresponding to that of the lesion.

Mr. *Delpech*, for making known the accidents occurring among workmen in the india-rubber business from the inhalation of sulphuret of carbon.

The Cuvierian prize, which is assigned every three years to the author of works in Natural History, was given this year to Prof. Richard Owen, who for more than twenty years, through works of great number and of elevated character, has contributed largely to comparative anatomy and palæontology. This prize was first given to Prof. Agassiz for his work on fossil fishes, and the second time to Prof. Müller of Berlin, for his researches on the structure and development of Echinoderms.

It is thus seen that in this year, as in others preceding, *foreign* men of science have taken a large part of the prizes, a fact highly honorable to the Academy of Sciences, showing that a right to its munificence does not rest in being a Frenchman, but in being worthy of it through actual labors.

Among the prizes to be given in January, 1858, there will be one on the application of steam navigation to naval operations. Three years since a similar prize was given, as we have mentioned. The new prize of 6000 francs aims to bring out new improvements especially with reference to the diminution of the amount of fuel for ships of war. Other improvements may also come from the combination of wind and steam. Moreover, naval architecture has not yet given in its last word. Engineers and men of science of all nations are invited to a competition, in which the desire is to reward inventions or improvements that

are substantiated by experience. The Academy leaves to the competitors an unlimited range, and wishes to secure some great step of progress, which shall be demonstrated practically, and if possible, also theoretically.

Society for the Aid of the Friends of Science.—There has just been established at Paris a society, the importance of which has been demonstrated by recent events. It is not forgotten that Laurent and Gerhardt died leaving a wife, and children under age, without a competence. Some subscriptions set on foot immediately, ameliorated somewhat their unfortunate condition, without proving very efficacious.* The society which has just been organized, has for its end, the establishment of a fund for the benefit of the families of men of science who may die without fortune. Their object is thus stated:—"The undersigned, considering that the cultivation of the sciences cannot be too much encouraged, and that those who give themselves to it with zeal sometimes so exhaust their resources as to leave their families at death in need, have resolved to form a society whose object shall be to give aid to the unfortunate that may be worthy of their consideration."

This society is formed under the patronage of M. Thenard, and the prominent savants of France have joined it. The subscription is ten francs per year. Independently of these subscriptions, the society will receive with proper recognition, gifts or bequests which may be made to it.

History of Science. Iron bridges.—On the occasion of a claim of priority raised by Mr. Ross, a bibliographic investigation was commenced respecting the history of iron bridges. Mr. Ross, in fact, wrote to the Academy on the subject of a model of a bridge entirely of iron, which was presented to that society in 1787 by an Englishman of the name of Payne. A record of this has been found in the archives of the Academy. A commission, consisting of Bossut, Borda, and Rochon, at the session of the 29th of August, 1787, made a favorable report on this project. The plan was for a single arch of 400 feet span, and it was to have been made partly of wrought iron and partly of cast. In the historical notice which forms the preamble of the Report, the commission, after mentioning different bridges of iron that had been only projected, dwelt at some length on a bridge which

* We alluded in 1853 to the subscription undertaken in that year for the widow and children of Laurent. Another has just now been started for the widow and three children of Gerhardt: it is a subscription of a new kind, under which the minimum contribution is 100 francs; and in exchange for this sum, the subscriber receives the Treatise on Organic Chemistry which Gerhardt was bringing to a close when he died. Each copy is accompanied with a notice written by M. Cahours and an autograph of Gerhardt. A similar subscription has been opened in London, in Switzerland, in Germany, and in the different Faculties of France. I feel confident that the scientific men of the United States will not be behind their confrères of Europe.

had been executed some years before—the bridge of Colebrook-Dale, thrown over the Severn. It consisted of a single arch of 100 feet span, and was constructed about the year 1779. It was built entirely of cast iron, and the commission state that at the time at which they wrote, it seemed to have suffered nothing from use or from alternations of heat and cold. It should be added that at the same session, when this report was presented, a locksmith of Paris, named Clement, brought forward plans for different parts of an iron bridge, which he proposed to build.

The last paragraph of this Report is interesting, as it shows the state of the iron industry in 1787. "We conclude, in view of all that has been exhibited, that the construction is simple and solid, and fitted to resist the weight and wear to which it will be exposed, and that it deserves to be tried: and finally, that it will furnish an example of the application of a metal which has not been enough used on a great scale, although on many occasions it has been employed with success."

Could the savants Bossut, Borda and Rochon return to the world they would see their views fully realized.

Astronomical News.—The prize established by Lalande for astronomical discovery, has been divided this year between Messrs. Chacornac, Goldschmidt, and Pogson of Oxford; the first for his discovery of two planets, Leda and Letitia, on the 12th of January and 8th of February, 1856; to the second for the discovery of Harmonia and Daphne, the 31st of March and 22d of May, 1856; and to the last for the discovery of the planet Isis, the 42d of the asteroids; the first four of these were earliest seen at Paris, the last at Oxford in England.

When Sir John Herschel was at the Cape of Good Hope, he was much troubled by his speculum; it tarnished constantly, and after five or six days was unfit for service. The same difficulty is encountered in all observatories. In his position as physicist to the observatory, M. Foucault has been led to take up the subject, and he has proposed as an improvement, that, for the *metallic* speculum, one should be substituted made of glass well polished and coated with silver after Drayton's process, that is, by the slow reduction of the nitrate of silver by means of an essential oil. When taken from the bath, the coating of silver is dull, but it is readily polished by friction with a skin covered with a little English red: it acquires, in a few moments, a brilliant lustre and gives fine reflections.

Although we cannot affirm that the lustre of this new speculum will be of long duration, there is at least reason to hope well of it, since silver is less alterable than copper and bronze; but even if it becomes dull it is as easily polished as at first.

Electric Telegraph. Submarine cable across the British Channel.—In consequence of a terrible gale, the two submarine cables

between the coast at Calais and Ostende and the English coast at Dover was broken by a vessel dragging its anchor over them. For some time after this, England had no communication with the continent except by the way of Holland. The Calais connection has now been reëstablished. The engineer charged with this work made use of the opportunity to examine the cable at the place of rupture, and he states that the conducting wires were perfectly uninjured in their envelop of gutta percha notwithstanding the five years' immersion in sea-water.

Scientific Voyages.—Since the scientific expedition was sent out last year to the northern seas by the French prince, an Austrian prince has projected a similar expedition; and more wise than his confrère of France, he has equipped it with a scientific corps. The corps will consist of distinguished and competent men, such as Dr. Scherzer, Moritz Wagner, Frauenfeld, Hochstetter, Zelebor.

The following is the plan of the voyage. The frigate leaves Trieste early in March, 1857. It will visit the principal ports of South America, double the Cape of Good Hope, touch at Ceylon, visit the English, French and Dutch possessions in India, the accessible ports of China, thence pass to Oceanica, touch at New Caledonia, Australia, New Zealand, Tahiti, etc., coast along Central and South America, and traversing the straits of Magellan, return to Trieste, in the spring of 1859. This is the first Austrian Exploring Expedition. The vessel is the frigate Novara, of 44 guns.

Chemical Facts. Different states of Sulphur.—Among the chemical researches in France during the last few months, we would refer to those of Berthelot on sulphur, the allotropic states of which element have appeared to be numerous and varied. Berthelot reduces all to two principal states, viz. that of *octahedral sulphur*, soluble in sulphuret of carbon, and that of *amorphous sulphur*, insoluble in this sulphuret. The former he calls *electro-negative* sulphur, for it acts always as a supporter of combustion, and separates from compounds in which it plays an electro-negative part (as SH, S^2C). The insoluble sulphur, on the contrary, is combustible or *electro-positive*, and separates from compounds in which it plays an electro-positive part (SO^2, SO^3, S^2O^2, S^3O^4). Under a similar relation, Berthelot brings with reason the allotropic states of selenium and phosphorus, which have, as is known, each a state soluble and insoluble in sulphuret of carbon. The two conditions of oxygen, ozone and ordinary oxygen, are to be considered as dependant on different electrical states, the ozone electro-negative, and ordinary oxygen electro-positive.

Now that the true principle has been indicated, it will be easy to find analogous facts, for it is one that will prove to be fertile in its applications.

Magnesium, Boron, Aluminium.—We owe to M. H. St.Claire Deville a series of facts of great interest, to which we can here only allude.

Magnesium is volatile like zinc, and may be as easily distilled; it also fuses at the same temperature, and burns with a bright flame, in the midst of which some points of indigo blue may be distinguished; at the same time it disengages a white cotton-like oxyd, like that of zinc, which is fixed and infusible. These are but a few points from the researches of Deville and Caron, at the laboratory of the Normal School.

The results respecting *boron* are communicated by Deville and Wöhler. Wöhler recently visited Paris to compare his results with those of Deville. It appears that crystallized boron is akin to the diamond; it has very nearly its hardness, and may be of great use when hard stones are wanted in watch or clock making, or their powder for grinding, especially grinding glass. Crystallized boron is obtained by reducing boric acid by means of aluminium; it forms borate of alumina and boruret of aluminium, and from the latter at a lower temperature boron separates, just as graphite in the cooling of fused iron.

Waters of Artesian Wells.— On examining the waters of the Artesian well of Grenelle with reference to the gases present, M. Peligot has ascertained that they contain not the least trace of air. Subterranean waters ought therefore to be *aerated* before being used as an aliment, and accordingly they are about to construct at Grenelle a species of tower, from the top of which the water will descend in innumerable threads, so as to present as much surface as possible to the air.

Photography. The regular Universal Exhibition by the French Photographic Society.—This exhibition is open and is remarkable for the magnificent display of pictures it affords: and they are numerous in spite of the severity of the jury of admission. All the processes are represented, from the Daguerrian plate to dry collodion, including moist collodion, albumen, albuminized collodion, waxed paper, chloridized albumen, etc., with all the methods of fixing pictures employed, and all kinds of photography. There are portraits, landscapes, buildings, panoramic views, etc. Only photographs from living nude subjects, called "Academies," are excluded.

The arrangement of the pictures is according to the nations contributing them. Visitors stop in crowds before the photogalvanographs exhibited by M. Pretsch, representing objects such as the Venus of Milo, the Cathedral of Strasburg, with a finish and beauty which would make us believe that they had been touched up with a graver, if men of truth had not on their honor affirmed the contrary.

The sea scenes of Mr. LeGray are much admired. They represent ships under way with full sail, a stormy sea, clouds floating in the air and crossed by a beam of the sun, all instantaneously taken. There are also photo-lithographic pictures on steel exhibited by Mr. Nègre, and proofs on paper designed for transparent views, and printed in the photographic printing establishment of Blanquart-Everard de Lille. There are casts (clichés) obtained by means of collodion on gutta percha rendered transparent by a process invented by M. Perret, a modest workman of Paris. These sheets of collodion have colossal dimensions, being about a meter high and eighty-eight centimeters wide; they are nearly as light as a spider's web.

Bibliography.—At the book establishment of Hachette, at Paris, the following works, in 12mo, have appeared:

L. FIGUIER: *The Scientific and Industrial Annual*, containing an exposition of the scientific works, inventions, and principal scientific applications which in 1856 attracted public attention in France and other lands. A similar volume appears each year.

A. YSABEAU: *Gardening, or the art of making and keeping a garden.*

HERVÉ and DELANOYE: *Voyages in the ice of the Arctic Pole* in search of a northwest passage; extracts from different voyages.

LEONIE D'AUNET: *Voyage of a woman to Spitzbergen.*

T. DE LANOYE: *The India of the present era:* with an introduction giving a brief history of these regions so rich and interesting.

CH. DREYSS, Professor at the Lyceum of Versailles: *Universal Chronology*, followed with a list of ancient and modern states. This Chronology comes down to 1852.

A. CHERUEL: *Historical Dictionary of the Institutions, Manners and Customs of France.* 2 vols. of 564 pages in two columns. The work is preceded by an introduction which gives a chronological catalogue of the institutions, or the *public* life, and the progress of manners, or the *private* life, of the French.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On a new biacid alcohol.*—LIMPRICHT has found that chlorbenzol, $C_{14}H_6Cl_2$, is the chlorid of a radical yielding a new bibasic alcohol analogous to Wurtz's glycol. The preparation of the pure alcohol is attended with difficulty in consequence of the facility with which it is converted into oil of bitter almonds, but Limpricht has prepared various ethers which leave no doubt as to the correctness of his views. Ethyl-benzol ether may be prepared by the action of chlorbenzol upon ethylate of soda. It is an oil with an agreeable odor and having the formula $\left.\begin{matrix} C_{14}H_6 \\ (C_4H_5)_2 \end{matrix}\right\} O_4$.

Aceto-benzolic ether is prepared by the action of chlorbenzol upon acetate of silver. It forms colorless crystals which have the formula $\left.\begin{matrix}C_{14}H_6\\(C_4H_3O_2)_2\end{matrix}\right\}O_4$. The action of aqueous ammonia upon aceto-benzolic ether yields acetamid and hydrobenzamid. The author suggests that hydrobenzamid is tribenzolamin, $C_{42}H_{18}N_2=N_2\left\{\begin{matrix}C_{14}H_6\\C_{14}H_6\\C_{14}H_6\end{matrix}\right.$, and that stilben may be the radical benzol, $C_{28}H_{12}=\left.\begin{matrix}C_{14}H_6\\C_{14}H_6\end{matrix}\right\}$, and benzoin benzolic ether, $C_{28}H_{12}O_4=\left.\begin{matrix}C_{14}H_6\\C_{14}H_6\end{matrix}\right\}O_4$.—*Ann. der Chemie und Pharmacie*, ci, 291.

[*Note.*—As there are few substances in organic chemistry more interesting or more important than the oil of bitter almonds, it appears desirable to have a single word for it in place of its present inconvenient appellation. I suggest the name *picramol* as appropriate and convenient. —W. G.]

2. *On the action of light upon chlorid of silver.*—GUTHRIE has instituted a few experiments which tend to show that the blackening of chlorid of silver by light, as supposed by Scheele, is due to the liberation of chlorine and the deposition of metallic silver. When dry chlorid of silver was exposed to light in a sealed tube, chlorine was found to be present in a free state. The blackening took place in benzol boiled so as to expel air. The gray mass of altered chlorid was heated with ammonia, which left a slaty grey substance which took the metallic lustre under a pestle, and was soluble in nitric acid and precipitated by chlorhydric acid, but not by ammonia. In another experiment the quantity of silver reduced and the quantity of chlorine set free were both weighed as chlorid of silver, and the weight found to agree as nearly as could be expected, also the quantity of chlorid of silver yielded by the metallic silver reduced agreed with the theoretical quantity. The blackening took place under nitric acid concentrated or dilute, and the quantity of chlorid found by the black matter agreed nearly with the amount of chlorid which should be yielded by pure silver.—*Quarterly Journal of the Chemical Society*, x, 74.

3. *On the use of the prism in qualitative analysis.*—GLADSTONE has studied the colors of various salts by means of the prism, and has made an interesting and valuable contribution to a branch of physico-chemistry heretofore too much neglected. The author employed in the analysis of liquids a wedge-shaped glass vessel, so placed that the line of light from the window traversed different thicknesses of the liquid and was then analyzed by means of a prism. The appearances as thus seen are easily transferred to paper, as Fraunhofer's lines are under favorable circumstances distinctly visible. As a general result, the author states that all the compounds of a particular base or acid have the same effect on the rays of light. Exceptions to this law occur, though very rarely. As it would not be possible to understand the author's special results without the aid of figures, and as our limits will not permit us to give all his details, we shall content ourselves with a sketch of the characters of the salts of a few metals. The difference in color between certain chromium salts vanishes entirely when the solutions are examined in the manner pointed out,

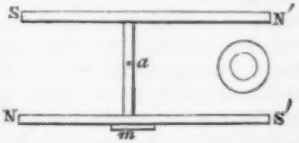
The red and blue solutions of cobalt do not greatly differ in their spectra, and the same is the case with the green and blue salts of copper. The ammonical salts of copper give however a very different prismatic appearance. All the salts of sesquioxyd of iron absorb the more refrangible rays, leaving the least refrangible to penetrate almost any thickness. The chromates exhibit a remarkable analogy in their spectra though sometimes very different to the eye, but there is a wide difference between the compounds of sesquioxyd of chromium and chromic acid. The general law laid down by the author is shown remarkably in the colors of litmus, the neutral acid and alkaline solutions of this substance yielding spectra which are only modifications of a common type. In compounds of two colored bodies the chromatic effect of the components persists so that it is often difficult to determine whether two bodies have combined or not. The author draws the following conclusions as of value in analysis. From the fact of the transmission of a particular ray we may infer that none of those bodies which usually absorb that ray are present in any kind of combination. The employment of the wedge and prism will often present some familiar spectral appearance which is at once distinctive, although the unassisted eye cannot determine the source of the color. The author in conclusion suggests that when a systematic comparison of different spectra shall have been made and regular tables of comparison constructed, the prism will take its place among the recognized instruments of the laboratory.—*Quarterly Journal of the Chemical Society*, x, 79. W. G.

4. *On the Disposition of Force in Paramagnetic and Diamagnetic Bodies;* by Professor TYNDALL, F.R.S. (Proc. Roy. Inst. of Great Britain, vol. ii, p. 159).—The notion of an attractive force, which draws bodies towards the centre of the earth, was entertained by Anaxagoras and his pupils, by Democritus, Pythagoras, and Epicurus; and the conjectures of these ancients were renewed by Galileo, Huyghens, and others, who stated that bodies attract each other as a magnet attracts iron. Kepler applied the notion to bodies beyond the surface of the earth, and affirmed the extension of this force to the most distant stars. Thus it would appear, that in the attraction of iron by a magnet originated the conception of the force of gravitation. Nevertheless, if we look closely at the matter, it will be seen that the magnetic force possesses characters strikingly distinct from those of the force which holds the universe together. The theory of gravitation is, that every particle of matter attracts every other particle; in magnetism also we have the phenomenon of attraction, but we have also, at the same time, the fact of repulsion, and the final effect is always due to the difference of these two forces. A body may be intensely acted on by a magnet, and still no motion of translation will follow, if the repulsion be equal to the attraction. A dipping needle was exhibited: previous to magnetization, the needle, when its centre of gravity was supported, stood accurately level; but, after magnetization, one end of it was pulled towards the north pole of the earth. The needle, however, being suspended from the arm of a fine balance, it was shown that its *weight* was unaltered by its magnetization. In like manner, when the needle was permitted to float upon a liquid, and thus to follow the attraction of the north magnetic pole of the earth, there was

no motion of the mass towards the pole referred to; and the reason was known to be, that although the marked end of the needle was *attracted* by the north pole, the unmarked end was *repelled* by an equal quantity, and these two equal and opposite forces neutralized each other as regards the production of a motion of translation. When the pole of an ordinary magnet was brought to act upon the swimming needle, the latter was attracted,—the reason being that the attracted end of the needle being much nearer to the pole of the magnet than the repelled end, the force of attraction was the more powerful of the two; but in the case of the earth, the pole being so distant, the length of the needle was practically zero. In like manner, when a piece of iron is presented to a magnet, the nearer parts are attracted, while the more distant parts are repelled; and because the attracted portions are nearer to the magnet than the repelled ones, we have a balance in favor of attraction. Here then is the most wonderful characteristic of the magnetic force, which distinguishes it from that of gravitation. The latter is a simple unpolar force, while the former is duplex or polar. Were gravitation like magnetism, a stone would no more fall to the ground than a piece of iron towards the north magnetic pole: and thus, however rich in consequences the supposition of Kepler and others may have been, it was clear that a force like that of magnetism would not be able to transact the business of the universe.

The object of the evening's discourse was to inquire whether the force of diamagnetism, which manifested itself as a repulsion of certain bodies by the poles of a magnet, was to be ranged as a polar force, beside that of magnetism; or as an unpolar force, beside that of gravitation. When a cylinder of soft iron is placed within a helix, and surrounded by an electric current, the antithesis of its two ends, or in other words, its polar excitation, is at once manifested by its action upon a magnetic needle; and it may be asked why a cylinder of bismuth may not be substituted for the cylinder of iron, and its state similarly examined. The reason is, that the excitement of the bismuth is so feeble, that it would be quite masked by that of the helix in which it is enclosed; and the problem that now meets us is, so to excite a diamagnetic body that the pure action of the body upon a magnetic needle may be observed, unmixed with the action of the body used to excite the diamagnetic.

How this may be effected, was illustrated in the following manner:—an upright helix of covered copper wire was placed upon the table, and it was shown that the top of the helix attracted, while its bottom repelled, the same pole of a magnetic needle; its central point, on the contrary, was neutral, and exhibited neither attraction nor repulsion. This helix was caused to stand between the two poles N′ S′ of an astatic magnet; the two magnets S N′ and S′ N were united by a rigid cross piece at their centres, and suspended from the point *a*, so that both magnets swung in the same horizontal plane. It was so arranged that the poles N′ S′ were opposite to the central or neutral point of the helix, so that when a current was sent through the latter, the magnets were unaffected by the



current. Here then we had an excited helix which itself had no action upon the magnets, and we were thus at liberty to examine the action of a body placed within the helix and excited by it, undisturbed by the influence of the latter. The helix was twelve inches high, and a cylinder of soft iron six inches long suspended from a string and passing over a pulley could be raised or lowered within the helix. When it was so far sunk that its lower end rested upon the table, the upper end found itself between the poles N S, attracting one of them and repelling the other, and consequently deflecting the astatic system in a certain direction. When the cylinder was raised so that the upper end was at the level of the top of the helix, its lower end was between the poles N′ S′; and a deflection opposed in direction to the former one was the immediate consequence. To render these deflections more visible to the audience, a mirror *m*, was attached to the system of magnets; a beam of light thrown upon the mirror was reflected and projected as a bright disk against the wall of the theatre; the distance of this image from the mirror being considerable, and its angular motion double that of the latter, a very slight motion of the magnet was sufficient to produce a displacement of the image through several yards. This then is the principle of the beautiful apparatus* by which the investigation now brought forward was conducted. It is manifest that if a second helix be placed between the poles S N with a cylinder within it, the action upon the astatic magnet may be exalted. This was the arrangement made use of in the actual inquiry. Thus to intensify the feeble action, which it is here our object to seek, we have in the first place neutralized the action of the earth upon the magnets, by placing them astatically. Secondly, by making use of two cylinders, and permitting them to act simultaneously on the four poles of the magnets, we have rendered the deflecting force four times what it would be, supposing only a single pole to be used. Finally, the whole apparatus was enclosed in a suitable case, which protected the magnets from atmospheric currents, and the deflections were read off through a glass plate in the case, by means of a telescope and scale placed at a considerable distance from the instrument.

A pair of bismuth cylinders was first examined. Sending a current through the helices, and observing that the magnets swung perfectly free, it was first arranged that the cylinders within the helices had their central points opposite to the poles of the magnets. All being at rest the number on the scale marked by the cross wire of the telescope was 572. The cylinders were then moved so that two ends were brought to bear simultaneously upon the magnetic poles: the magnet moved promptly, and after some oscillations† came to rest at the number 612; thus moving from a smaller to a larger number. The other two ends of the bars were next brought to bear upon the magnet: a prompt deflection was the consequence, and the final position of equilibrium was 526; the movement being from a larger to a smaller number. We thus observe a manifest polar action of the bismuth cylinders upon the magnet; one pair of ends deflecting it in one direction, and the other pair deflecting it in the opposite direction.

* Devised by Prof. W. Weber, and constructed by M. Leyser, of Leipzig.

† To lessen these a copper damper was made use of.

Substituting for the cylinders of bismuth thin cylinders of iron, of magnetic slate, of sulphate of iron, carbonate of iron, protochlorid of iron, red ferrocyanid of potassium, and other magnetic bodies, it was found that when the position of the magnetic cylinders was the same as that of the cylinders of bismuth, the deflection produced by the former was always opposed in direction to that produced by the latter: and hence the disposition of the force in the diamagnetic body must have been precisely antithetical to its disposition in the magnetic ones.

But it will be urged, and indeed has been urged against this inference, that the deflection produced by the bismuth cylinders is purely due to the currents of induction excited in the mass by its motion within the helices. In reply to this objection, it may be stated, in the first place, that the deflection is permanent, and cannot therefore be due to induced currents, which are only of momentary duration. It has also been urged that such experiments ought to be made with other metals, and with better conductors than bismuth, for if due to currents of induction the better the conductor the more exalted will be the effect. This requirement was complied with.

Cylinders of antimony were substituted for those of bismuth. This metal is a better conductor of electricity, but less strongly diamagnetic than bismuth. If therefore the action referred to be due to induced currents we ought to have it greater in the case of antimony than with bismuth; but if it springs from a true diamagnetic polarity, the action of the bismuth ought to exceed that of the antimony. Experiment proves that the latter is the case, and that hence the deflection produced by these metals is due to their diamagnetic, and not to their conductive capacity. Copper cylinders were next examined: here we have a metal which conducts electricity fifty times better than bismuth, but its diamagnetic power is nearly null; if the effects be due to induction we ought to have them here in an enormously exaggerated degree, but no sensible deflection was produced by the two cylinders of copper.

It has also been proposed by the opponents of diamagnetic polarity to coat fragments of bismuth with some insulating substance, so as to render the formation of induced currents impossible, and to test the question with cylinders of these fragments. This requirement was also fulfilled. It is only necessary to reduce the bismuth to powder and expose it for a short time to the air to cause the particles to become so far oxydized as to render them perfectly insulating. The power of the powder in this respect was exhibited experimentally in the lecture; nevertheless, this powder, enclosed in glass tubes, exhibited an action scarcely less powerful than that of the massive cylinders.

But the most rigid proof, a proof admitted to be conclusive by those who have denied the antithesis of magnetism and diamagnetism, remains to be stated. Prisms of the same heavy glass as that with which the diamagnetic force was discovered, were substituted for the metallic cylinders, and their action upon the magnet was proved to be precisely the same in kind as that of the cylinders of bismuth. The inquiry was also extended to other insulators: to phosphorus, sulphur, nitre, calcareous spar, statuary marble, with the same invariable result: each of these substances was proved polar, the disposition of the force being the same as

that of bismuth and the reverse of that of iron. When a bar of iron is set erect, its lower end is known to be a north pole, and its upper end a south pole, in virtue of the earth's induction. A marble statue, on the contrary, has its feet a south pole, and its head a north pole, and there is no doubt that the same remark applies to its living archetype; each man walking over the earth's surface is a true diamagnet, with its poles the reverse of those of a mass of magnetic matter of the same shape and in a similar position.

An experiment of practical value, as affording a ready estimate of the different conductive powers of two metals for electricity, was exhibited, for the purpose of proving experimentally some of the assertions made by the speaker in reference to this subject. A cube of bismuth was taken and suspended by a twisted string between the two poles of an electro-magnet. The cube was attached by a short copper wire to a little square pyramid, the base of which was horizontal, and its sides formed of four small triangular pieces of looking-glass. A beam of light was suffered to fall upon this reflector, and as the reflector followed the motion of the cube the images cast from its sides followed each other in succession, each describing a circle of about thirty feet in diameter. As the velocity of rotation augmented, these images blended into a continuous ring of light. At a particular instant the electro-magnet was excited, currents were evolved in the rotating cube, and the strength of these currents, which increases with the conductivity of the cube for electricity, was practically estimated by the time required to bring the cube and its associated mirrors to a state of rest. With bismuth this time amounted to a score of seconds or more: a cube of copper, on the contrary, was struck almost instantly motionless when the circuit was established.

5. *On M. Petitjean's process for Silvering Glass;* by Professor FARADAY, D.C.L., F.R.S. (Proc. Roy. Inst. of Great Britain, vol. ii, p. 308).—M. Petitjean's process consists essentially in the preparation of a solution containing oxyd of silver, ammonia, nitric and tartaric acids, able to deposit metallic silver either at common or somewhat elevated temperatures; and in the right application of this solution to glass, either in the form of plates or vessels. 1540 grains of nitrate of silver being treated with 955 grains of strong solution of ammonia, and afterwards with 7700 grains of water, yields a solution, to which when clear 170 grains of tartaric acid dissolved in 680 grains of water are to be added, and then 152 cubic inches more of water, with good agitation. When the liquid has settled, the clear part is to be poured off; 152 cubic inches of water to be added to the remaining solid matter, that as much may be dissolved as possible; and the clear fluids to be put together and increased by the further addition of 61 cubic inches of water. This is the silvering solution No. 1. A second fluid, No. 2, is to be prepared in like manner, with this difference, that the tartaric acid is to be doubled in quantity. The apparatus employed for the silvering of glass plate consists of a cast-iron table box, containing water within, and a set of gas burners beneath to heat it: the upper surface of the table is planed and set truly horizontal by a level, and covered by a varnished cloth: heat is applied until the temperature is 140° Fah. The glass is well cleaned, first with a cloth; after which a plug of cotton, dipped in the silvering fluid and a little polishing powder,

is carefully passed over the surface to be silvered, and when this application is dry it is removed by another plug of cotton, and the plate obtained perfectly clean. The glass is then laid on the table, a portion of the silvering fluid poured on to the surface, and this spread carefully over every part by a cylinder of india-rubber stretched upon wood which has previously been cleaned and wetted with the solution; in this manner a perfect wetting of the surface is obtained, and all air bubbles, &c. are removed. Then more fluid is poured on the glass until it is covered with a layer about the $\frac{1}{10}$th of an inch in depth, which easily stands upon it; and in that state its temperature is allowed to rise. In about ten minutes or more, silver begins to deposit on the glass, and in fifteen or twenty minutes a uniform opaque coat, having a greyish tint on the upper surface, is deposited. After a certain time the glass employed in the illustration was pushed to the edge of the table, was tilted that the fluid might be poured off, was washed with water, and then was examined. The under surface presented a perfectly brilliant metallic plate of high reflective power, as high as any that silver can attain to; and the coat of silver, though thin, was so strong as to sustain handling, and so firm as to bear polishing on the back to any degree, by rubbing with the hand and polishing powder. The usual course in practice, however, is, when the first stratum of fluid is exhausted, to remove it, and apply a layer of No. 2 solution; and when that has been removed and the glass washed and dried, to cover the back surface with a protective coat of black varnish. When the form of the glass varies, simple expedients are employed; and by their means either concave or convex, or corrugated surfaces are silvered, and bottles and vases are coated internally. It is easy to mend an injury in the silvering of a plate, and two or three cases of repair were performed on the table.

The proposed advantages of the process are,—the production of a perfect reflecting surface; the ability to repair; the mercantile economy of the process (the silver in a square yard of surface is worth 1*s.* 8*d.*); the certainty, simplicity, and quickness of the operation; and, above all, the dismissal of the use of mercury. In theory the principles of the process justify the expectations, and in practice nothing as yet has occurred which is counter to them.

6. *Some observations on divided gold;* by Prof. Faraday, D.C.L., F.R.S. (ib., p. 310).—With regard to the second part of the evening's discourse, the speaker said he had been led by certain considerations to seek experimentally for some effect on the rays of light, by bodies which when in small quantities had strong peculiar action upon it, and which also could be divided into plates and particles so thin and minute as to come far within the dimensions of an undulation of light, whilst they still retained more or less of the power they had in mass; and though he had as yet obtained but little new information, he considered it his duty, in some degree, to report progress to the members of the Royal Institution. The vibrations of light are, for the violet ray 59,570 in an inch, and for the red ray 37,640 in an inch; it is the lateral portion of the vibration of the ether* which is by hypothesis supposed to affect the

* Analogous transverse vibration may easily be obtained on the surface of water or other fluids, by the process described in the Philosophical Transactions for 1831 p. 336, &c.

eye, but the relation of number remains the same. Now a leaf of gold as supplied by the mechanician is only $\frac{1}{280,000}$ of an inch in thickness, so that seven and a half of these leaves might be placed in the space occupied by a single undulation of the red ray, and five in the space occupied by a violet undulation. Gold of this thickness and in this state is transparent, transmitting green light, whilst yellow light is reflected; there is every reason to believe also that some is absorbed, as happens with all ordinary bodies. When gold leaf is laid upon a layer of water on glass, the water may easily be removed, and solutions be substituted for it; in this way a solution of chlorine, or of cyanid of potassium, may be employed to thin the film of gold; and as the latter dissolves the other metals present in the gold (silver, for instance, which chlorine leaves as a chlorid), it gives a pure result; and by washing away the cyanid, and draining and drying the last remains of water, the film is left attached to the glass: it may be experimented with, though in a state of extreme tenuity. Examined either by the electric lamp, or the solar spectrum, or the microscope, this film was apparently continuous in many parts where its thickness could not be a tenth or twentieth part of the original gold leaf. In these parts gold appeared as a very transparent thing, reflecting yellow light and transmitting green and other rays; it was so thin that it probably did not occupy more than a hundredth part of a vibration of light, and yet there was no peculiar effect produced. The rays of the spectrum were in succession sent through it; a part of all of them was either stopped or turned back, but that which passed through was *unchanged* in its character, whether the gold plate was under ordinary circumstances, or in a very intense magnetic field of force.

When a solution of gold is placed in an atmosphere containing phosphorus vapor the gold is reduced, forming films that may be washed and placed on glass without destroying their state or condition: these vary from extreme thinness to the thickness of gold leaf or more, and have various degrees of reflective and transmissive power; they are of great variety of color, from grey to green, but they are like the gold leaves in that they do not change the rays of light.

When gold wires are deflagrated by the Leyden discharge upon glass plates, extreme division into particles is effected, and deposits are produced, appearing, by transmitted light, of many varieties of color, amongst which are ruby, violet, purple, green, and grey tints. By heat many of these are changed so as to transmit chiefly ruby tints, retaining always the reflective character of gold. None of them affect any particular ray selected from the solar spectrum, so as to change its character, otherwise than by reflection and absorption; what is transmitted still remains the same ray. When gold leaf is heated on glass the heat causes its retraction and running together. To common observation the gold leaf disappears, and but little light is then reflected or stopped: but if pressure by a polished agate convex surface be applied to the gold in such places, reflective power reappears to a greater or smaller degree, and green light is again transmitted. When the gold films by phosphorus have been properly heated, pressure has the same effect with them.

If a piece of clean phosphorus be placed *beneath* a weak gold solution, and especially if the phosphorus be a clear thick film, obtained by the

evaporation of a solution of that substance in sulphid of carbon, in the course of a few hours the solution becomes colored of a ruby tint; and the effect goes on increasing, sometimes for two or three days. At times the liquid appears clear, at other times turbid. As far as Mr. Faraday has proceeded, he believes this fluid to be a mixture of a colorless transparent liquid, with fine particles of gold. By transmitted light, it is of a fine ruby tint; by reflected light, it has more or less of a brown yellow color. That it is merely a diffusion of fine particles is shown by two results; the first is, that the fluid being left long enough the particles settle to the bottom: the second is, that whilst it is colored or turbid, if a cone of the sun's rays (or that from a lamp or candle in a dark room) be thrown across the fluid by a lens, the particles are illuminated, reflect yellow light, and become visible, not as independent particles, but as a cloud. Sometimes a liquid which has deposited much of its gold, remains of a faint ruby tint, and to the ordinary observation, transparent; but when illuminated by a cone of rays the suspended particles show their presence by the opalescence, which is the result of their united action. The settling particles, if in a flask, appear at the bottom, like a lens of deep colored fluid, opaque at the middle, but deep ruby at the edges; when agitated they may be again diffused through the liquid. These particles tend to aggregate into larger particles, and produce other effects of color. It is found that boiling gives a certain degree of permanence to the ruby state. Many saline and other substances affect this ruby fluid: thus, a few drops of solution of common salt being added, the whole gradually becomes of a violet color; still the particles are only in suspension, and when illuminated by a lens are a golden yellow by reflected light: they separate now much more rapidly and perfectly by deposition from the fluid than before. Some specimens, however, of the fluid, of a weak purple or violet color, remain for months without any appearance of settling, so that the particles must be exceedingly divided; still the rays of the sun or even of a candle in a dark room, when collected by a lens, will manifest their presence. The highest powers of the microscope have not as yet rendered visible either the ruby or the violet particles in any of these fluids.

Glass is occasionally colored of a ruby tint by gold; such glass, when examined by a ray of light and a lens, gives the opalescent effect described above, which indicates the existence of separate particles; at least such has been the case with all the specimens Mr. Faraday has examined. It becomes a question whether the constitution of the glass and the ruby fluids described is not, as regards color, alike. At present, he believes they are; but whether the gold is in the state of pure metal, or of a compound, he has yet to decide. It would be a point of considerable optical importance if they should prove to be metallic gold; from the effects presented when gold wires are deflagrated by the Leyden discharge over glass, quartz, mica, and vellum, and the deposits subjected to heat, pressure, &c., he inclines to believe they are pure metal.

II. MINERALOGY AND GEOLOGY.

1. *On the probable origin of some Magnesian Rocks;* by T. Sterry Hunt, (in a letter to one of the Editors.)—It is well known that certain mineral waters when exposed to the air deposit large quantities of carbonate of lime, and that the beds of travertine thus produced at the present day, often form extensive rock masses. We cannot doubt that some ancient limestones have had a similar origin, and among these, portions of the *sparry limestones* of Eaton in the Hudson River group, which sometimes exhibit the agatized structure and texture of alabaster. The various deposits of carbonate of lime thus formed, often contain iron as oxyd or as carbonate, besides a great variety of other elements including many of the metals, but magnesia is always wanting in them, or present only in traces. Berzelius remarked in his analysis of the waters and the travertine of the Carlsbad springs, that the large portion of carbonate of magnesia which the water contains, remains dissolved after the precipitation of the lime, and is only separated by evaporation. The precipitate produced in a solution of a magnesian salt by the addition of carbonate of soda is redissolved by an excess of the magnesian or the alkaline salt, but the evaporation of the liquid deposits the magnesian carbonate in a granular form.

In my investigations of mineral springs of the Lower Silurian Rocks of Canada, I have found certain waters containing common salt with large amounts of chlorid of calcium and magnesium, but destitute of carbonates; there are other saline waters, which, with less of earthy chlorids, give by evaporation large amounts of earthy carbonates, in which the magnesia prevails, sometimes almost to the exclusion of lime. These springs apparently owe their origin to the admixture of waters of the first-mentioned class with those of the alkaline springs, so common in the same region, and in which carbonate of soda predominates. By the careful addition of carbonate of soda to such a water, nearly the whole of the lime may be precipitated while a great part of the magnesia remains in solution. The spontaneous evaporation of such magnesian waters arising from the action of carbonate of soda upon sea-water or that of the springs above mentioned, would give rise to beds of magnesian carbonate, either pure or mingled with carbonate of lime.

Such deposits occur in Canada, in the form of thin layers, interrupted beds, or lenticular masses, interstratified with pure limestones, which sometimes appear to be travertines, and at others perhaps ordinary sedimentary limestones, holding orthoceratites, trilobites and other fossils of the Hudson River group. The magnesian beds are always granular, destitute of fossils, and generally mixed with sand or clay; they often pass into a veritable conglomerate, holding fragments of quartz or limestone. The carbonate is sometimes a dolomite, and at others a magnesite, destitute of lime, but a portion of carbonate of iron is never wanting. The pure carbonate of lime also, but more rarely, serve as the cement to quartzose sand or limestone pebbles, and the whole of these rocks are interstratified with the sandstones and shales, often graptolitic, which make up the great mass of the Quebec division of the above mentioned group.

I have already in a previous note indicated the manner in which I suppose these silicious and argillaceous magnesites and dolomites to have been in certain parts of the formation transformed by the intervention of solutions of alkaline carbonates into silicates, such as talc, serpentine, chlorite, pyroxenite, etc. A farther development of my views of the metamorphism of sediments, with the results of the investigation of a great many altered rocks will appear in the Report of Progress of the Geological Survey of Canada for the last three years—now in press.

Montreal, July 6th, 1857.

2. *Chlorids.*—At the recent eruption of Vesuvius (in 1855) Deville made some observations on the material issuing from fumaroles over the cooling lava, and found that there was no vapor of water, and that the chlorids of sodium and potassium predominated, while there were sulphates in small quantities, no fluorids, and perhaps some carbonic acid. The uncondensable gases he has not yet satisfactorily examined. Higher above where the heat is less, the smell of sulphurous acid was perceived, but the fumaroles still gave out almost exclusively chlorid gases. In places where the vapor of water was given out, as in the upper crater, sulphurous acid was more abundant and the odor of sulphuretted hydrogen was perceptible with perhaps vapor of sulphur; from a fumarole a considerable amount of water was condensed, upon which small crystals of sulphur floated. It appears therefore, that at the points of maximum intensity in an eruption, chlorids are given out without water; but in the places where the action is of the ordinary kind about the summit, sulphur and vapor of water are abundant.

3. *Agalmatolite;* by Dr. C. T. Jackson, (Proc. Bost. Soc. Nat. Hist., vi, 52.)—To this mineral is referred a rock with a soapy feel from the borders of the Deep River coal field, North Carolina. It afforded Dr. Jackson on analysis, $\dot{S}i$ 75·00, $\dot{A}l$ 18·75, $\dot{K}$ 2·09, $\dot{H}$ 3·50 = 99·25 with traces only of oxyd of iron. It is ground up and sold in New York at $40 a ton, making a delicate white substance satin-like in feel similar to China clay. It is supposed to be used in adulterating white lead and also fancy soaps, and for glazing or satinizing wall-paper.

4. *Corundum.*—Artificial crystals of sapphire have recently been obtained by using an ordinary crucible in a forge, by A. Gaudin (L'Institut, No. 1214). He mixed, in the crucible, lampblack, ammonia or potash alum previously calcined with an equal weight of sulphate of potash, and subjected the whole to a high heat for 15 minutes. He thus obtained the alumina crystallized without discoloration from a trace of iron or any other metal. The sulphuret of potassium produced through the reaction is regarded as an energetic solvent of the alumina, and from it the crystallization takes place, either through its evaporation or greater concentration.

5. *Slate rock of Hungary.*—A slate resembling talcose slate, from the Gabbro or Zipser in Hungary, and also much like the Sericite slate of Taurus contains, according to C. F. Chandler, (Inaug. Dissert.):

$\dot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$	$\dot{H}$
75·28	13·43	1·88	1·79	0·37	4·54	2·49=99·78.

Specific gravity 2·659.

6. *Notes on the Bermuda Islands;* by ANDREW SCOTT.—The group of Bermuda Islands is situated in the middle of the Atlantic, just on the border of the tropics, partaking of their fruitful climate without their heat and insalubrity, and of the north without its cold winters. It consists of three or four principal islands and several hundred smaller ones, enclosing picturesque bodies of deep and shallow water, and is nearly surrounded by reefs almost level with the sea, extending seven to ten miles from the shores; its greatest length from northeast to southwest is about eighteen miles. The islands are all composed of coral like the formation of the Bahamas and Florida reefs, but differ from them in that they are much more elevated, some of the hills being a hundred feet above the sea level. The soil is very scanty and supports naturally a stunted growth of red cedar, and when cultivated produces rich crops.

A process of nature is now going on in one of the principal islands, which, in connection with other facts may serve to show how they have been raised to their present height without supposing a convulsion or volcanic action.

The southern shores are bold; a heavy surf is constantly breaking in, converting the coral as fast as it forms into sand, and forming extensive beaches. The southwest winter gales at times are dreadfully severe; the wind has taken up this sand and drifted it in one place half a mile or more over the summit of the island, which is near one hundred feet high; it now covers land forty or fifty feet deep which but a few years ago was cultivated. This body of sand is in view from the town of Hamilton; it is fast increasing, and gives some anxiety to its inhabitants for fear that it may encroach upon their harbor.

Now the whole formation of the islands above the level of the sea is composed of just such sand, which, wherever it is exposed to salt water, in a short time becomes hard. The surface rocks on the seashore are very hard and rough, consisting for the most part of broken shells and corals cemented together by the action of (probably) the lime in the salt water. In the higher rocks there are no fossils; the few shells found are similar to living ones, and may have been carried up by birds; below the surface the rock quarries out as soft as chalk, and when used for building it becomes hard by saturating with lime-water. In the quarries and excavations for fortifications and roads, the formation is clearly exposed; it is all one kind, varying in hardness from loose sand to close-grained limestone, lying in irregular beds just as sand might be supposed to have drifted, and in some places showing a stratum or bed of soil identical with the present soil containing roots of the cedar and vegetable remains but no signs of ever having been under water. There are no marks of volcanic agency anywhere. There are several caverns and fissures near the shores, all with more or less of sea water in them, and so situated that they might have been hollowed out by the action of wind and water without any other extraordinary cause. Stalactites are found in these caverns. The water in wells does not rise above the level of the sea and is too brackish for use; the inhabitants depend upon rains.

The facts here stated of the geological formation of the Islands of Bermuda serve only to confirm the received theory of the formation of coral islands, and may not be new; but on account of their elevation and apparent stratification, some of the best informed gentlemen of Bermuda take a different view and ascribe it to an upheaving force.

7. *Note on the Cherokine of C. U. Shepard;* by T. Sterry Hunt. (From a letter to one of the editors, dated Quebec, June 23, 1857.)*—The specimen of cherokine was in small imperfect milk-white prisms forming a little layer on a fragment of a granular sulphuret of lead, copper, etc. (I did not carefully note them). The whole amount is not more than six or eight grains, so that I could not well determine its density. I took about half of it and found it to consist of *lead* with *phosphoric acid*, besides traces, too small to be estimated, of a whitish precipitate by ammonia in the filtrate from the PbS—it might be phosphate of lime, or possibly alumina, but was probably not one per cent of the mineral, which is a *pure pyromorphite*. Damour, however, found in some pyromorphites from Brittany variable amounts of hydrated alumina, up to sixteen per cent, constituting a passage into plumbo-resinite. I have from him a specimen of *crystalline aluminous pyromorphite*, which is associated with a pure phosphate, and Shepard may have analyzed something of the kind, although my crystals of cherokine are pure phosphate of lead.

8. *Notice of the Occurrence of Aragonite near the Arkansas River;* by W. J. Taylor.—It will be of interest to mineralogists to learn of the occurrence of aragonite, sixteen miles from the crossing of the Arkansas River on the north boundary of the Creek nation. It is found there in six-sided prisms with gypsum, imbedded in a ferruginous clay. The appearance of the crystals, together with the associated minerals, renders it impossible to distinguish some of the specimens of this locality, from some of those from Molina and Valencia, in Aragon, Spain. Dr. S. W. Woodhouse first brought specimens from this locality in 1850, and presented them to the Academy of Natural Sciences of Philadelphia. I am indebted to him for a specimen and for the facts relating to its occurrence. It is found in hills of considerable heights, which rise suddenly from the level surface of the prairie. The crystals obtained have a diameter of about three-eighths of an inch, but they were taken hastily from the cliffs without the means or the time necessary for making good selections.

9. *Descriptions of New Species of Fossils from the Cretaceous Formations of Nebraska, with observations upon Baculites ovatus and B. compressus, and the Progressive Development of the Septa in Baculites, Ammonites and Scaphites;* by James Hall and F. B. Meek. Communicated to the American Academy, June 27, 1844, and published in its Transactions, volume v, p. 380, 1855.—This important paper by Messrs. Hall and Meek, written three years since, though printed later, by some oversight has not been noticed in this Journal. The authors state in the first paragraph that the collections were made by Messrs. F. B. Meek and F. V. Hayden, and we understand that the excursion to the Nebraska regions was projected by Professor Hall and carried out at his expense. The paper contains descriptions of one crustacean and thirty-three new molluscan fossil species of the Nebraskan Cretaceous beds, and is illustrated by seven lithographic plates in 4to. It presents a comparison of the fossils with those of New Jersey, and alludes to the distinction between them and those of Texas. As this subject and that of the subdivisions of the beds are considered in detail in Professor Hall's

* The specimen of cherokine in Professor Hunt's hands was sent him by Professor Shepard, and the examination here mentioned was made at the request of J. D. Dana.—Eds.

article in this volume, p. 72, it is unnecessary here to recur to it again. The changes which age makes in the septa of species of Baculites is well exhibited. In the young the septa were found to be extremely simple, small undulations existing in place of the deep lobes and plications. The same is true of species of Scaphites and Ammonites, and a corresponding difference is apparent between the interior (or primal) and outer whorls of the shells. The paper observes that the fact, though not new with reference to the Ammonites, is for the first time announced with respect to the other two genera.

10. *Descriptions of new species of Fossils from the Carboniferous Limestones of Indiana and Illinois;* by JAMES HALL, (Trans. Albany Institute, vol. iv, pp. 1 to 37.)—This paper by Professor Hall contains descriptions of a large number of Carboniferous fossils, mostly molluscan. It includes of Pentremites, 2 species; Terebratula, 3; Spirifera, 2; Spirigera, 1; Retzia, 1; Rhynconella, 6; Orthis, 2; Productus, 2; Conocardium, 6; Nucula, 2; Cypricardella (n. gen.), 4; Cypricardia, 2; Euomphalus, 4; Pleurotomaria, 12; Murchisonia, 5; Loxonema, 2; Bulimella (n. gen.), 3; Holopea, 1; Natica, 2; Capulus, 1; Bellerophon, 2; Conularia, 1; Nautilus, 1; Orthoceras, 1; Cythere (Crustacean), 1; Spirorbis, 2; Rotalia, 1. These species are from the subcarboniferous limestone, and many of them from Spergen Hill and Bloomington, Indiana. The particular stratum is called the Second Archimedes or Warsaw limestone, lying above the Keokuk or lower Archimedes limestone. Professor Hall describes also one Terebratula from the coal measures, (*T. millepunctata*) which occurs at Topeka in Kansas, and also at Pecos village on the line of the Pacific Railroad surveyed by Lieut. Whipple.

11. *On the Cretaceous Fossils of Vancouver's Island, Western America,* by F. B. MEEK, (Trans. Albany Institute, vol. iv, p. 37.)—The fossils described by Mr. Meek were placed in his hands by Dr. J. S. Newberry, Geologist of Lieut. Williamson's North California and Oregon Exploring Expedition. The fossils noticed or described are *Cardium scitulum, Arca Vancouverensis, Nucula Traskana, Dentalium Nanaimoensis, Baculites ovatus* Say, *Ammonites* (Scaphites?) *ramosus, A. Newberryanus,* with fragments of Inoceramus, Bulla, Rostellaria; and from another rock of probably related age, *Pholadomya* (*Goniomya*) *borealis, P. subelongata, Thracia? occidentalis,* and *subtruncata, Arca* (*Cucullæa*) *equilateralis,* and *Trigonia Evansana.* The evidence is not positive that the fossils may not be older than the Cretaceous, though probably of that formation.

12. *Notes explanatory of a Map and Section illustrating the Geological Structure of the country bordering on the Missouri River, from the mouth of the Platte River to Fort Benton;* by Dr. F. V. HAYDEN, (Proc. Acad. Nat. Sci. Philadelphia, May, 1815.)—The mouth of the Platte is about in lat. 41° and long. 96°, and Fort Benton at lat. 47½°, and long. 110½°, so that Fort Benton is far north and west of the starting point, owing to the great curve of the Missouri to the west along lat. 47 and 48°. The map is derived from the most reliable records in the War Department, as is also the profile section for so many hundred miles. Attractive as have been the fossil developments in this territory, the country has been a terra incognita except to explorers. Now, however, we can begin to trace out the positions of the geological formations. We find the Carboniferous series in the northeast part of Kansas and southeast of Nebraska, passing under the Cretaceous on the west and also on the north near the mouth

of Platte River. Thence north over a wide extent the Cretaceous is spread out, dipping westward under the Tertiary of the Bad Lands of White River in lat. 43 to 44° perhaps, and terminated still farther north and west by the great Lignite Tertiary basin some hundred miles in extent, till above lat. 47° and long. 108 to 110° appears again the Cretaceous formation. Five vertical sections of the Cretaceous are given, No. 1 being found on the southeast at Platte River, and again on the northwest part of the long section at Fort Benton. The author of this paper, Dr. Hayden, has spent no small part of four years in the territory and has more fully explored its natural history than any other individual. This and the following paper are the results of explorations under the War Department. C. D.

13. *Descriptions of New Species and Genera of Fossils collected by Dr. F. V. Hayden in Nebraska Territory in* 1856, (Ibid.)—The new species described in this paper are about forty, under seventeen genera, of which two are new. Preceding these descriptions are important "Remarks on the Tertiary and Cretaceous Formations," filling nineteen pages and presenting full confirmation of the "parallelism" of these rocks with others over the country. Several sections of rocks, widely separated, are given for comparison, which with the fossils establish the "parallelism" announced in a preceding paper. An abstract would be too long for this place. The facts also tend to prove that the Tertiary of White River, that "Cemetery of Pre-Adamite Mammals," is Miocene, as first suggested by Dr. Leidy. For other interesting geological conclusions reference must be made to the paper itself, the joint labor of F. B. Meek and F. V. Hayden, M.D.

The scientific world is under much obligation to the War Department for these and other discoveries in the territories of the United States. Dr. Hayden was in 1856 with the party commanded by Lieut. G. K. Warren, U. S. Topographical Engineer, in Nebraska, and no partial credit is due to this officer for his interest and aid in the prosecution of geological discoveries. In advance of the final report of Lieut. Warren, this paper is permitted by the Hon. Secretary of War to be made public through the Academy of Sciences. C. D.

14. *North Carolina Mountains.*—The lofty peaks of western North Carolina were barometrically measured by Prof. Guyot, in July, 1856, with the following results. These twelve summits are all higher than Mount Washington in New Hampshire, which according to Professor Bache's survey is 6285 feet in height.

Name.	Height.
1. Clingman's Peak,	6701 feet.
2. Guyot's Peak (or Balsam Cone),	6661 "
3. Sandoz Knob,	6612 "
4. Hairy Bear,	6597 "
5. Cat-tail Peak,	6595 "
6. Gibbes' Peak,	6586 "
7. Mitchell's Peak,	6576 "
8. Sugar-Loaf (or Hallback Peak),	6401 "
9. Potatoe Top,	6389 "
10. Black Knob,	6377 "
11. Bowler's Pyramid,	6345 "
12. Roan Mountain,	6318 "

15. *Himalayas.*—According to recent surveys of the Himalaya mountains by Colonel Waugh, there is a loftier peak than the one that has long stood first in the books.

Dhualagiri, *Mount Everest* (the new peak), Kintschindjunga, and Tschumalari stand nearly in a line,—Dhualagiri being the westernmost,—between the meridians 83° 32′ and 89° 19′ east of Greenwich, and the parallels 28° 42′ and 27° 42′. The heights of the four are as follows:

Dhualagiri (lat. 28° 42′, long. 83° 32′), -	26,826
Mt. Everest (lat. 27° 59′, long. 85° 58′), -	29,002
Kintschindjunga (lat. 27° 42′, long. 88° 11′),	28,156
Tschumalari (lat. 27° 50′, long. 89° 19′), -	23,946

Petermann's Mitth. Geog., 1856, p. 379.

16. *Notes and Queries on the Drying up of the Yellow River, China;* by D. J. Macgowan, M. D.—We are accustomed to attach more importance to records of physical phenomena contained in the annals of China than most students of Chinese; yet we have never been able to give full credence to accounts of the temporary drying up of large rivers. The recent disappearance however, of a great part of the Hwang (Yellow river), must be regarded as explanatory, if not confirmatory of these fluviatile vicissitudes.

From beyond Süchau to its embouchure a distance of more than 200 miles, the Yellow River has been dry for several years!

On referring to records of similar phenomena we find the following:

In the year 1766 B. C. the I and Loh (tributaries of the Hwang) became dry. At or about the same time the Tai mountain, 200 miles distant in Shantung fell: a seven years drought occurred soon after.

About the year 1154 the Hwang, or Yellow River itself became dry.

In 778 B. C. an earthquake affected the basins of the King Loh and Wei (affluents of the Hwang) when these rivers dried up. The fall of a mountain, or a landslip also accompanied this convulsion.

In the year 310 of our era, the Yellow River was fordable at Honan, as were also the Loh and adjacent streams.

At the close of the Sung dynasty 1278 A. D. the Tsientang was so nearly dry at Hangchau as to be fordable. The opportunity it presented of crossing was embraced by the Mongols who were in pursuit of the last of the Sung emperors. The absence of tides for three days is assigned as the cause of this remarkable state of that river: an explanation which is obviously insufficient, even though the tidal wave had failed to rise.

Further research would probably extend this list. In history, these records are distinguished from those that relate to the shifting of channels, overflowing of banks, and other obstructions to which rivers are subjected.

We come now to our own days.

In the latter part of 1852 the people of Hwaingan found the river fordable: in the spring of the ensuing year travellers crossed it dry shod, since which time it has been, to use the Chinese term applied to it, "as dry as dust." We have in our employ the former Secretary of the Commissioner of the Grand Canal, who resided in Hwaingan from February to September, 1853. Nearly the whole of the following year he spent farther up the river at Süchau. The dryness of the channel at the former place attracted his attention, but he found prevailing such a superstitious

dread of the subject that people avoided conversing about it: it was believed that even politics might be discussed with less danger, the fear being, that if not let alone altogether, the dangerous stream might reappear, and with greater power. At Süchau, says our informant, a few puddles might be seen, and a rivulet which a child could ford. From various sources we learn that as high up as Kaifung there is so little water that boats can no longer approach the city. The subject is seldom referred to in the *Gazette*. In May last, the Commissioner having charge of the lower portion of the Hwang reported, that out of the twenty-two *ting* under his jurisdiction nine were entirely dry. Last May the emperor, in a sentential document, enumerating the calamitous occurrences of his short reign says, "*the* river does not flow as hitherto," evidently regarding that as an evil omen. A careful search of the *Gazette* of the past four years would perhaps throw more light on the subject; the above is all that we have noted.

It will be remembered that an earthquake was felt in the maritime portion of the Plain on the 16th December, 1852. Did the earthquake precede, was it synchronous with, or did it follow the fluviatile phenomenon?

In the following year earthquakes occurred over this same region April 15th, 24th and 25th. A newly formed part of the coast north of the Yangtz disappeared in one of those shocks. About the same time, for 15 successive days, destructive shocks were experienced in Kansuh. In 1854 several slight earthquakes were felt in the south of China and in the China sea; and in 1855 occurred the great earthquake at Simoda which as we have elsewhere stated in detail caused an elevation of the inland waters of the southeast corner of the Plain.

In the spring of the present year earthquakes were of frequent occurrence in Manchuria. In fine, the whole of southeast Asia, has within the past few years been disturbed by an extraordinary number of earthquakes. It is for dynamic geology, with which we are in no wise conversant, to inform us if there is any connection between these subterranean forces, and the change which has come over the Yellow River. Although no proper geodetical survey has been made, we know that a portion of the lower part of the Hwang is higher than the adjacent plain. A very slight elevation of that region of country would suffice to turn the waters into their ancient channels. We have indeed received verbal accounts from travellers to the effect that the stream now passes through the prefecture of Tsauchau in the southwest part of Shantung, and thence as of old, in what particular way is not stated, to the Gulf of Pechele. On the other hand the above named Secretary states that in his journey from Peking to Hwaingan made in February 1853 he found from Tientsing to that point on the canal where it receives the waters of the Yunho less water than usual, and from thence where the current turned in his favor the quantity of water in the canal became less and less until he reached its junction with the Yellow River where it also was dry. Moreover the waters were no where less pellucid than ordinary. From various other sources we have received similar accounts, which like this, palpably contradict the statements which represent the Hwang as having taken a northeast course. How could that vast sheet of water find its way into the Gulf without imparting its hue to the streams it invaded? Again how could the river find exit in the manner indicated without overflowing rivers the level of which in some places is above that

of the adjacent country, having dykes scarcely adequate to sustain their normal pressure? Yet no change is recorded in the condition of the streams entering into the Gulf of Pechele;—no floods;—it seems as if "Chinese sorrow" were assuaged by some wand unseen. There is confessedly much about that river which we do not know. We do know however that in bye-gone centuries it was a sad vagrant, and that ever since the palmy days of the Patriarchal emperor Yu, (the first, if not the greatest of civil engineers) it has been an unconscionable spendthrift. No good therefore could be expected to come of it; yet for it to terminate so mysteriously that to find its end, one is obliged to rush into print, is what we never expected. Has the earth opened and swallowed up this trouble of China, that is to say, did the earthquake which appears to have elevated the seaward part of its bed, leave parallel chasms into which the waters descended through the alluvial bottom? If so, what was thence their course?—*North China Herald.*

Ningpo, November 1st, 1856.

17. *A Sketch of the Geology of Tennessee*, embracing a description of its minerals and ores, their variety and quality, modes of assaying and value, with a description of its soils and productions and palæontology; by RICHARD O. CURREY, M.D., late Professor of Chemistry and Geology in the East Tennessee University. 128 pp., 8vo, with a map.—This small work gives a brief description of the rocks of the State, and contains a large engraved geological map from the report of Professor Safford, the State Geologist, noticed in a former volume of this Journal. The pages were written as a popular account of the mineral resources of the State, and first published to a considerable extent in the newspapers and a medical journal of Tennessee. The material has been rearranged in the preparation of the volume. The author often accompanied Dr. Troost in his excursions and dedicates his work to this distinguished geologist. In 1854 he published a geological map of the State, and he announces in his preface that he is engaged on a general work entitled "The Geology of the Southern States."

18. *Devonian Trees.—Fossil wood* is announced by J. W. DAWSON (Proceedings Amer. Assoc., 10th meeting, p. 174) as occurring in the Devonian sandstones of Gaspé. The wood was black and silicified, being a trunk four feet long, and seven to nine and a half inches in diameter. A cross section exhibited a distinct cellular tissue, with circular, not crowded, cells; and there were well-defined rings of growth, averaging about a line in breadth. In a vertical section, the cells were seen to be elongated and to terminate in conical points; they showed traces of transverse and diagonal fibres, sometimes decussating, but no medullary rays or disc structures were visible. The tree was referred to the Coniferæ, but stated to differ materially from any previously observed form. The author adds that it may be related to fossil trees of the Devonian "Cypridina schists" of Saalfield in Meiningen, described by Professor Unger as of very singular organization as if the prototypes of the "Gymnosperms."

19. *Crinoids.*—An important paper on the Devonian Crinoids from the vicinity of Coblentz on the Rhine, by F. Zeiler and Ph. Wirtgen, and illustrated by 12 plates is contained in the Verhandlungen des naturhistorischen Vereins, Bonn. 1855, p. 17 and 79.

III. BOTANY AND ZOOLOGY.

1. *Journal of the Proceedings of the Linnæan Society*, Vol. I, No. 4, concluding the volume. 1857.—The Botanical portion contains thirteen articles, nearly all of them short ones. Mr. Berkeley contributes a note on the Recent Discoveries in relation to the microgonidia [or androspores] of Fresh-water Algæ, viz. those of Pringsheim in *Vaucheria* and *Œdogonium*, &c. The main object of the communication is to record the fact,—now that the interesting nature and function of these bodies have been demonstrated,—that Mr. Thwaites had observed and made sketches of them in *Œdogonium* more than ten years ago, and conjectured them to be antheridia.*

Mr. Currey describes a new *Peziza*, being the full development of *Sclerotium roseum*.

Mr. Bennett describes a new Leguminous genus, *Guibourtia*, the Kobotree of Sierra Leone, allied to *Copaifera*, and producing one of the kinds of Africal copal largely exported from that country to England; and Mr. Archer gives some account of this substance.

Dr. Seemann follows with a communication, On the Palm of Timbuctoo, and identifies it, through information supplied by Drs. Barth and Vogel, with the *Borassus? Æthiopum* of Von Martius.

Mr. Berkeley, adverting to the statement that a coarse kind of bread is said to be made in Siberia and Lapland from the rootstocks of *Pteris aquilina*, the common Brake, and to the well known fact that those of a probable variety of the same species, *P. esculenta*, furnished the New Zealanders with a large part of their food, undertook to prepare a sort of bread from the rootstocks of the English plant. After digesting the prepared pulp in water for twenty-four hours and washing away the abundant and ill-flavored slimy matter, it was kneaded into a cake and baked. "The result was a coarse but palatable food, perfectly free from any disagreeable flavor, much better,—and probably not less nutritious,—than Cassava bread."†

Mr. Berkeley next describes some Entomogenous *Sphæriæ*, premising that: "No country in the world seems to abound more in *Fungi* than the United States. I have something approaching to 5000 species in my herbarium from two or three of the Southern States alone; and it is quite certain, from the new forms which are constantly occurring, that the number is far from being exhausted." Those here described are five new species of *Cordyceps* (collected by Mr. Ravenel and Dr. Curtis), all probably growing out of larvæ of different insects. They are all figured on an accompanying plate.

Mr. Masters describes a monstrosity of *Saponaria officinalis*, in which the (usually bifid) crown or scale of the petals was transformed, more or

* An abstract of the results reached by Pringsheim, and also by Cohn, &c. &c.—in their recent most interesting contributions to our knowledge of reproduction in the lower Cryptogamia,—demonstrating true sexual reproduction in these simple plants,—will be given in an ensuing number of this Journal.

† In the *Gardener's Chronicle* for July 18th, Mr. Bell calls attention to a passage in the *English Chronicle* for 1377 to 1461, published by the Camden Society, showing that in time of famine the people in the north of England were accustomed to make bread of Fern-roots.

less completely, into a pair of stamens, or a forked and biantheriferous filament; and so he concludes that the scales are composed of two abortive stamens united, "and in consequence that these two bodies do not constitute any real exception to the laws of alternation," nor arise from a transverse chorisis of the petal. But the advocates of *chorisis* will find no difficulty in these facts, and, agreeing with the writer in the Journal of Botany for 1849, that the scale belongs to the petal, will also maintain that its evolution into a double stamen in this case affords no proof nor presumption that the scale really represents a pair of true adnate stamens (any more than, *per contra*, the half-petal, half-stamen bodies of a semi-double Rose or Camellia are morphologically petals), so long as the theory of *collateral chorisis* is not invalidated,—since that theory just as well explains the double stamen of the case in hand as it does any other case. The same monstrous flowers clearly showed the carpellary origin of the ovules; and so perhaps as really do the normal blossoms of the same plant, with complete dissepiments at the base of the ovary.

Mr. Currey describes and figures (plate 2) a new species of *Pilolobus*.

Professor Lindley contributes a note on *Spiranthes gemmipara*, of the west coast of Ireland, and shows that it is neither our American *S. cernua* (as had of late been supposed, see p. 384 of this volume), nor *S. Romanzoffiana*. To this succeeds the longest paper in the faciculus, viz. Prof. Lindley's Contributions to the Orchidology of India, No. 1. "To nothing, perhaps, more remarkable does an examination of Indian Orchids lead, than to the unexpected fact that they show certain species to have a most extensive geographical distribution. Hitherto it has been believed that these plants are extremely local, and such is probably the case with epiphytes; but it is quite the reverse with terrestrial species, the range of some of which proves to be as wide as that of the most ubiquitous species belonging to other natural orders." This is illustrated by examples. We are interested to find that *Goodyera repens* inhabits the Sikkim Himalayas; and that Dr. Hooker also found there a *Tipularia*, which is characterized as a distinct species, but is not unlikely to be a mere variety of our own rare (but my no means local) *T. discolor*.

Mr. Oliver describes certain glandular appendages of the leaves in the autumnal rosettes of *Epilobium montanum;* and, finally, Dr. Hicks describes a new British species of *Draparnaldia*.

Since the foregoing notice was written, No. 5, or the first fasciculus of the second volume, has come to hand. The botanical portion comprises the following articles, besides the commencement of one from Dr. Thomson.

On the Cultivation of Mosses, by the Rev. H. H. Higgins. Mr. H. relates his experience in cultivating various mosses—about 240 species—in a *bryarium*, on the Ward-case principle.

Synopsis of the Genus Clitoria; by GEORGE BENTHAM.—The important points of general interest are, first, the union of *Neurocarpum* of Desvaux with this genus, for the same reason that the author reunites *Tetragonolobus* with *Lotus;* giving up the character, as generic, of a raised nerve or wing along the centre of the valves of the pod. Besides its being unaccompanied by other characters, in *Clitoria* it proves to be inconstant in the same species or even in the same individual. Mr. Bentham proceeds to remark that: "The external forms acquired by fruits in their development from the ovary to maturity, and especially the foliaceous appendages they assume, are sometimes irrespective of their organic struc-

ture, and appear then of little more consequence than the foliaceous wings or appendages on the branches, inflorescences, or calyx-tubes. So also the form of the membranous expansions of samaroid fruits, the consistence of pericarps, the number and arrangement on the calyx and other foliaceous appendages of the oleaginous deposits, called *transparent glands* in *Leguminosæ*, *Hypericineæ*, &c., or *vittæ* in *Umbelliferæ*, useful as they all may be in certain cases, as indicative of general organic differences, have yet *per se* but little absolute value in classification. This absolute reliance, in supposed conformity to general principles, upon such characters, even when unaccompanied by any other differences, is one of the sources whence botanical science is daily inundated by torrents of new genera, which threaten ere long completely to drown all system. Where the presence or absence of these appendages or glands, or any peculiarity in their arrangement, appears to be consequent upon a general difference in the plan of the fruit or in the habit of the plant, or is accompanied by corresponding characters in other organs, it should be carefully attended to. But where one or more species of a natural genus differ from the rest by some such external peculiarity in the development of the fruit alone, it seems against all principles laid down for a natural method, to take that peculiarity as a generic character, merely because it is a carpological one."

Another point brought to view is the until now unsuspectedly wide range of our *Clitoria Mariana*, which on the one hand extends from New Jersey to southern Mexico, while on the other it reappears in eastern India, viz. in the Khasiya mountains and Tavoy;—an interesting and unexpected addition to the list of such species recently published in this Journal. The writer adds that a Himalayan *Amphicarpæa* is so closely allied to our North American species, that the difference would probably vanish in a fuller suite of specimens. There is another Indian and Javan species of the same North American type:—"a fact which calls to mind how frequently large American genera (such as *Eupatorium*, *Aster*, *Solidago*, *Solanum*, &c.) are represented in Eastern Asia by a small number of species, which gradually diminish or disappear altogether as we proceed westward towards the Atlantic limits of Europe; whilst the types peculiar to the extreme west of Europe (excluding of course the Arctic flora) are wholly deficient in America. These are among the considerations which suggest an ancient continuity of territory between America and Asia under a latitude, or at any rate with a climate, more meridional than would be effected by a junction through the chains of the Aleutian and Kurile Islands."

Præcursores ad Floram Indicam; by Drs. Hooker and Thomson.—This is the first of a series of promised articles, which must for the present take the place of a continuation of the *Flora Indica:* it comprises the Indian *Stylidieæ* (3 species), *Goodenovieæ* (2 species), and *Campanulaceæ*, the latter including *Lobeliaceæ* as a tribe. There is no denying that this union is made on correct principles. But *Solanaceæ* should be combined with *Scrophulariaceæ* on the same grounds, as they probably would have been except for the great size of these families. Dr. Hooker has noticed dimorphous flowers in some species of Campanula, the abnormal ones being minute and "destitute of corolla and stamens" [?];—an interesting observation, but less novel than he supposes. For Linnæus (*Hort. Ups.* p. 40, so described the flowers of *Campanula* (*Specularia*) *per-*

foliata; Ruiz and Pavon figured them in *C. biflora;* Dr. Torrey noticed them independently in his *Flora of the Northern States* more than thirty years ago, and in 1830 described their true structure, (see also his *Flora of New York*, 1, p. 428). Since then, although overlooked by DeCandolle, they have been observed and investigated by Brongniart (*Jussieu, Mem. Malpigh.* in *Archives du Museum*, 3, p. 84), &c.—The vexed question of the principles of limitation of genera being raised, is discussed from a practical point of view by Dr. Hooker and Mr. Bentham; and an interesting note on the principles of generic nomenclature is drawn up by Mr. Bentham, in a separate article, which, being brief and important, we cite entire:—

Memorandum on the Principles of Generic Nomenclature, as referred to in the preceding paper; drawn up by G. Bentham, Esq., F.L.S.—"Two of the chief objects of the systematist in botany are, first, to collect plants into natural groups of successively higher value and greater scope according to their mutual affinities; and, secondly, to fix upon certain stages of these successive groups to which names should be attached for the purpose of reference. It is to the latter of these objects that we would now chiefly direct our attention.

"The grand object accomplished by Linnæus in his nomenclature was to create a language by which plants could be spoken of, and by means of which groups of species (called *genera*) could be referred to, classed, and treated of as easily as the species themselves.

"He accordingly, treating his genera as *entities* (to use a word of Jeremy Bentham's) as natural as species, distributed them for practical purposes into his well-known artificial Classes and Orders.

"The evident facilities for scientific study afforded by this grouping of species into natural genera, prompted Jussieu to carry the principle much higher; and, whilst he retained the Linnean genera as the basis of botanical language, he established, for the purposes of science, his *natural orders* or groups of genera, which are in fact nothing more than genera of a higher grade; and he distributed these orders or large genera into classes and subclasses. This system of—

Species grouped into natural genera,
Genera grouped into natural orders, and
Orders arranged in classes more or less natural;

with a language of—

Substantive names for the genera,
Adjective adjuncts for the species, and
Substantively taken adjectives for the orders,

has been ever since universally followed in theory, but has been most inconveniently departed from in practice.

"With the great increase in the number of species known, and the increased facilities for the study of affinities afforded by the Linnean language and the Jussieuan principles, botanists became aware that the species of a genus and the genera of an order could be collected into intermediate groups, as natural and as well defined as the genera and orders themselves; and that names were, for scientific purposes, as useful for these subordinate groups as for those genera or orders.

"To carry this into practice two different courses have been adopted:—

"1. To maintain the original genera and orders in their integrity (except where a mistaken view of their affinities required them to be remodelled),

calling the lower groups formed for scientific purposes *subgenera*, *sections*, *subsections*, *divisions*, &c., or *suborders*, *tribes*, *subtribes*, *divisions*, &c., as the case may be;—to maintain the original names for the purposes of language;—and, for the purposes of science, to give to the subordinate groups substantive or substantively taken adjective names as the case may be, whenever these subordinate groups are so well defined or so natural, that, *but for the convenience of language*, they might have made good genera or orders;—and, when these subordinate groups are less defined or less natural, either to give them no names at all, distinguishing them by figures or signs such as *, **, &c., or §1, §2, &c., or to give them mere adjective names.

"Or 2ndly. To consider even the lowest of these intermediate groups between species and original genera, or between genera and original orders, as so many independent genera or orders, with their corresponding substantive or substantively taken adjective names expected to be introduced into ordinary botanical language.

"The first of these courses appears to be the only one which can save botanical nomenclature from replunging into the chaos in which Linnæus found it. It was strongly advocated by the elder DeCandolle; although in the latter years of his life, seeing how general was the disposition to convert his subgenera and sections into genera, and his suborders and tribes into orders, he himself more or less gave in to the general practice. The same principle was adopted by Endlicher, but he again was disposed to go too far in giving substantive names to purely technical or ill-defined subsections of genera.

"The second course is that which is now unfortunately but too general. Independently of a natural pride we all feel in establishing new genera or orders, it is felt how useful it is, in the study of affinities, to define correctly and give names to all natural groups of every grade, however numerous they may be, and how easy it is, in the immense variety of language, to coin these names indefinitely; but it is not perceived that in attempting to introduce them all into ordinary botanical language, the memory is taxed beyond the capabilities of any mind, and the original and legitimate object of the Linnean nomenclature is wholly lost sight of. In a purely scientific point of view it matters little if the orders are converted into classes or alliances, the genera into orders, and the sections and subsections into genera; their relative importance does not depend on the names given to them, but on their height in the scale of comprehensiveness; but, for language, the great implement, without which science cannot work, it is of the greatest importance that the groups which give their substantive names to every species they include should remain large. If, independently of the inevitable increase of genera by new discoveries, such old ones as *Ficus*, *Begonia*, *Arum*, *Erica*, &c. are divided* into ten, twenty, thirty or forty independent ones, with names and characters to be recollected before any one species can be spoken of, if genera are to be reckoned by tens of thousands instead of thousands, the range of any individual botanist will be limited to a small portion of the whole field of the science. So also, as long as the number of orders

* And it must be borne in mind, that if genera so eminently natural and universally recognized as these, are to be thus subdivided and renamed for ordinary botanical parlance, so may *Carex*, *Rubus*, *Salix*, and hundreds of other equally well-established genera.

can be kept within, or not much beyond a couple of hundred, it may reasonably be expected that a botanist of ordinary capacity shall obtain a sufficient general idea of their nature and characters to call them at any time individually to his mind for the purpose of comparison; but double that number, and all is confusion.

"This inevitable confusion and the necessity of maintaining in some way the larger groups have been perceived by those even who have gone the farthest in lowering the scale of orders and genera. As a remedy they propose to erect the old genera into independent orders, and the old orders into classes or alliances. This is but an incomplete resumption of the old principles without the advantages of the old nomenclature.

"It must be recollected that, although we choose a well-defined and natural group as the one to which we give a generic name, yet this is no indication that the group is considered as the *best* defined, or better defined than the group immediately above it; on the contrary it is frequently less so. It is by no means pretended that *Urostigma* or *Pharmacosyce* are better defined than the old genus *Ficus*, or that the new genera that have lately been cut out of the old genus *Begonia* form more natural groups than *Begonia* itself does; but the principle in these cases seems to be adopted, that the lowest definable group above a species is a genus. Go a step farther, and every species becomes a genus with a substantive name!

"And let it not be forgotten, that although the analytical process carried to the uttermost is necessary for the purpose of ascertaining the facts upon which botanical science is based, it is a judicious synthesis alone which can enable the human mind to take anything like a comprehensive view of those facts, to deduce from them the principles of the science, or to communicate to others either facts or principles."

The philosophical side of the question remains to be discussed. It is much to be wished that Mr. Bentham would bring his sound judgment, logical acumen, and rich store of knowledge to bear upon the principles of botanical classification in general, and the grounds in nature upon which our systems rest. If *species*, and they alone, are the true subjects of classification; if the relationship of species is what the naturalist endeavors to express in the forms of genera, orders, classes, &c.; if these relationships are very various in degree, and even indefinite, so that the grades of affinity or groups they indicate are not always (and perhaps not generally) completely circumscribed in nature; and if, consequently, the definition of genera, &c. involves questions not of *things*, between which absolute distinctions might be drawn, but of *degrees of resemblance*, which may be expected to present indefinite gradations; then the suggestions of this article are as philosophical as they are practically useful, and the proper limitation of genera and other groups,—always the decisive test of a naturalist's genius—is a matter of sound judgment and sagacity, enlightened by wide experience, and not of arbitrary rules deduced from any preconceived system. A. G.

2. *Synopsis Plantarum Phanerogamicarum novarum omnium per annos* 1851–1855 *descriptarum;* auctore Dr. Carolo Mueller; or: Walpers *Annales Botanices Systematicæ*, tom. iv, fasc. 1. Leipsic, 1857. —Dr. Müller, it will be seen from this double title, has commenced a continuation of that necessary repertory of newly published species of plants, variously dispersed through memoirs, journals, and systematic works,

which the sudden death of Dr. Walpers arrested in the year 1850. Dr. Müller's first fasciculus, just issued, contains 160 pages, which are all occupied with the accessions in the few orders from *Ranunculaceæ* to *Nymphæaceæ*. This results not from an accumulation of new genera and species, but from the plan of the work and the style of printing being considerably altered, but not we think improved for the purpose in view. The principal part of this fasciculus is made up from the first volume of Hooker and Thomson's *Flora Indica*, and Tulasne's Monograph of *Monimiaceæ*, two books which every working botanist may be presumed to possess or have access to. So it was not worth while to copy detailed descriptions in full. Then, again, synonyms and varieties are displayed in separate paragraphs, and the page is in other respects so open that one might suspect it was intended to make the printed matter occupy the greatest amount of space, instead of the least. The more condensed a work of this kind is the better. While well-known and substantial works are so copiously abstracted from, rarer ones which we could mention and some scattered publications have been overlooked. Notwithstanding these faults, botanists can not be otherwise than thankful to Dr. Müller for carrying on so laborious and so necessary an undertaking. A. G.

3. *Bertoloni, Miscellanea Botanica;* fasc. 15 and 16 (1854, 1856, Bologna.)—About a quarter of a century ago Professor Bertoloni received from an American correspondent a set of a well-known collection of dried plants made in Alabama by the late Dr. Gates, and distributed by the New York Lyceum of Natural History. In 1844, in an evil hour, he began to publish new species from these materials. The extraordinary stupidity of the Italian Professor's determinations,—which may be judged of from the specimens already recorded in the pages of this journal,—would be simply amusing, if it were not for the trouble they give to botanists, in swelling most needlessly the lists of synonyms, already a serious hindrance to the progress of the science. It is just because Bertoloni's determinations are so very bad that they require to be noticed at all. For, as he rarely hits the family correctly, to say nothing of the genus, the ordinary means of correcting his mistakes are inapplicable. Fortunately rude figures of the proposed new genera and species are generally given; and these, with a knowledge of what Gates's collection contained, enable us to ascertain what the plants in question really are. We had hoped that the precious stock was exhausted, but the 15th and 16th fascicles of the *Miscellanea Botanica* afford the following novelties, viz.:

Potamogeton delicatulum, Bertol., which is P. hybridus of Michaux.

Convolvulus condensatus, which is

Gentiana gracillima, which is Nuttall's Apteria setacea, a well-known Burmanniaceous plant.

Hibiscus trisectus, described from foliage, without flowers or fruit, is the *Tread-softly* of the South, Cnidoscolus stimulosa.

Polygala Pseudosenega, although described as having rose-colored flowers, is pretty evidently P. lutea, a well-marked yellow-flowered species.

Marshallia dentata, is Gaillardia lanceolata, the rayless state, already notorious for having been formerly mistaken for *Polypteris, Nutt.* by DeCandolle.

Myriophyllum fulvescens is Proserpinaca pectinacea of Lamarck.

Besides these supposed new species, what Bertoloni names *Schrankia uncinata* is evidently *S. angustata*. A. G.

4. *Phycologia Australica, or Figures and Descriptions of Australian Seaweeds*, is the title of an illustrated work on the marine botany of Australia, announced by Dr. Harvey, Professor of Botany in the University of Dublin, on the plan of his *Phycologia Britannica*, so well known and so admirable. It is to be published by Mr. Reeve (if the number of subscribers' names warrant the undertaking), in fifty monthly parts, each with six colored plates and as many pages of letter-press, at three shillings sterling per part; and will contain the choicest fruits of the author's recent labors and discoveries upon the Australian shores. A. G.

5. *Indigofera Caroliniana*, of Walter, the common Wild Indigo-plant of the Southern United States, as Mr. Niesler informs us, is commonly used by the country people in Georgia in place of *I. tinctoria*, and it yields an indigo which to all appearance is equal to the commercial article. "Just when it is beginning to bloom, the old wives collect from the woods as much of the plant as they can procure; they steep it in water some twenty-four hours, until it assumes a greenish tinge, when the liquid is drawn off and *churned* until it assumes its proper blue color: it is then *curdled* by the addition of a small quantity of ley from wood ashes, and allowed to settle; the sediment is then collected, put into coarse bags and drained dry, and it is then used in the same way as the ordinary commercial article. Those who have used it most insist that the color is better and more permanent than that of the exotic indigo, and that the same quantity of the plant will yield much more than *I. tinctoria*. They are in the habit of cutting it three or four times in the season from the same root. Sometimes they gather the seed and sow it in convenient places, where it will flourish and yield a supply for years. It seems likely that this wild indigo might be made a profitable crop in the South; with this great advantage, that it would be produced on lands now waste and useless for any other purpose."—*H. M. Niesler, in litt.* A. G.

6. *The Crustacea and Echinodermata of the Pacific shores of North America;* by Wm. Stimpson. From the Journal of the Boston Society of Natural History, vol. vi, 92 pp. 8vo, with six plates. Cambridge: 1857.

Prodromus Descriptionis Animalium Evertebratorum, &c. Part II by Wm. Stimpson. Proceed. of the Acad. Nat. Sci. Philadelphia, 1857.

Mr. Stimpson has a great work before him in the description of the species of invertebrates which he collected in the recent North Pacific Expedition. In the first of these pamphlets he takes up the Crustacea and Echinoderms of the North American shores in that ocean. He elaborates with great care and skill, and appears to make sure work in his descriptions of species. With regard to the Crustacea, he states that now nearly 130 species of this region are known; among these there are many Maioids, but five Cancroids (four of the genus Cancer and one of Ozius) and none of the Portunidæ. The Lithodia group contains ten species. Mr. Stimpson adopts the generic name Eupagurus of Brandt instead of Bernhardus of Dana, the former having the priority of the latter by a month or two. He adds the *Cancer antennarius* to those of Cancer before described; and the Hippa of the California shores he makes a new species, the *H. analoga*. Besides these, his memoir includes many new species and some new genera.

The second pamphlet contains brief descriptions of new species of the Turbellaria Nemertinea, collected by the author in the course of the same expedition.

HELIOCENTRIC NEBULOUS RING.

PLATE V.

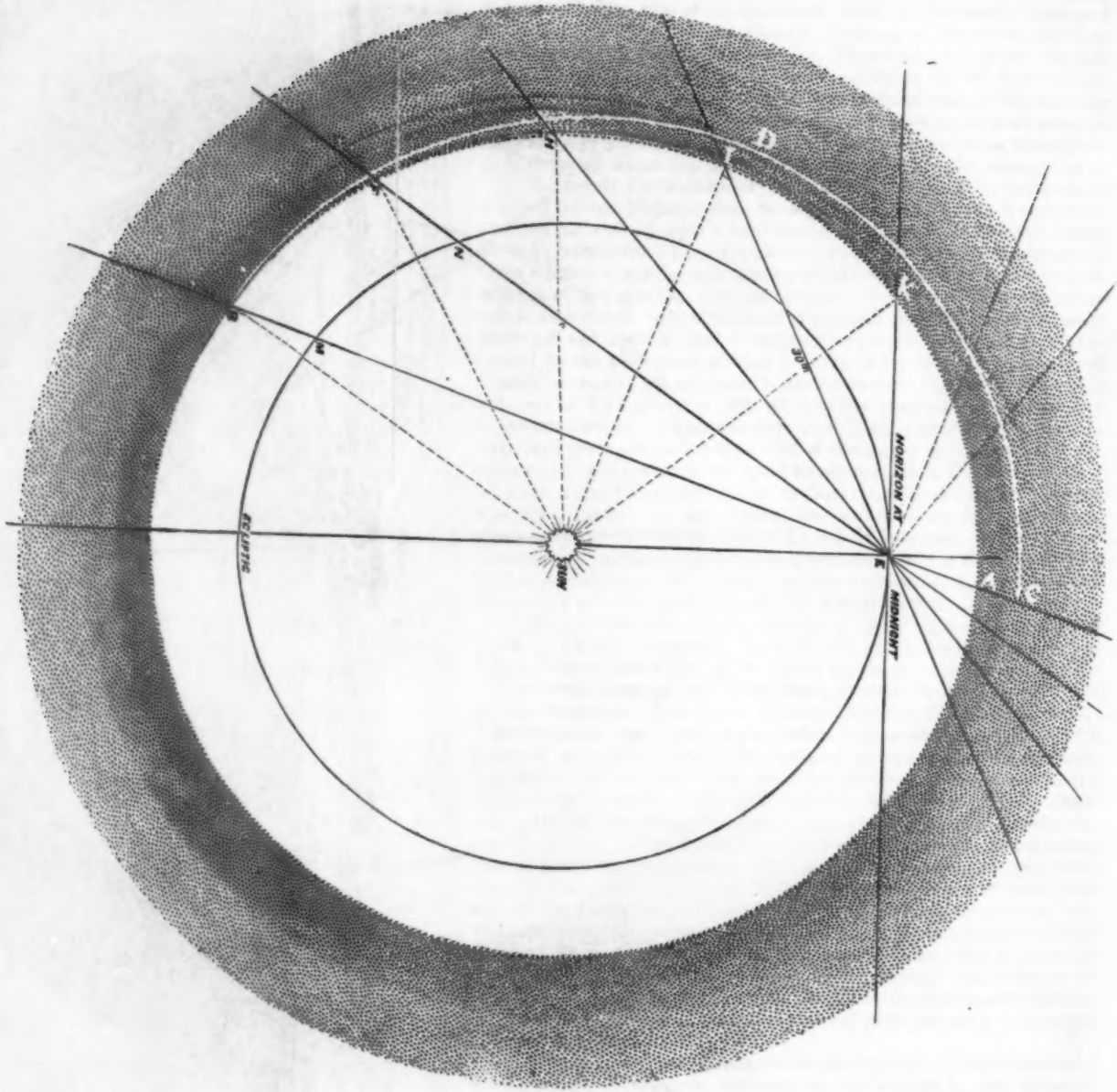
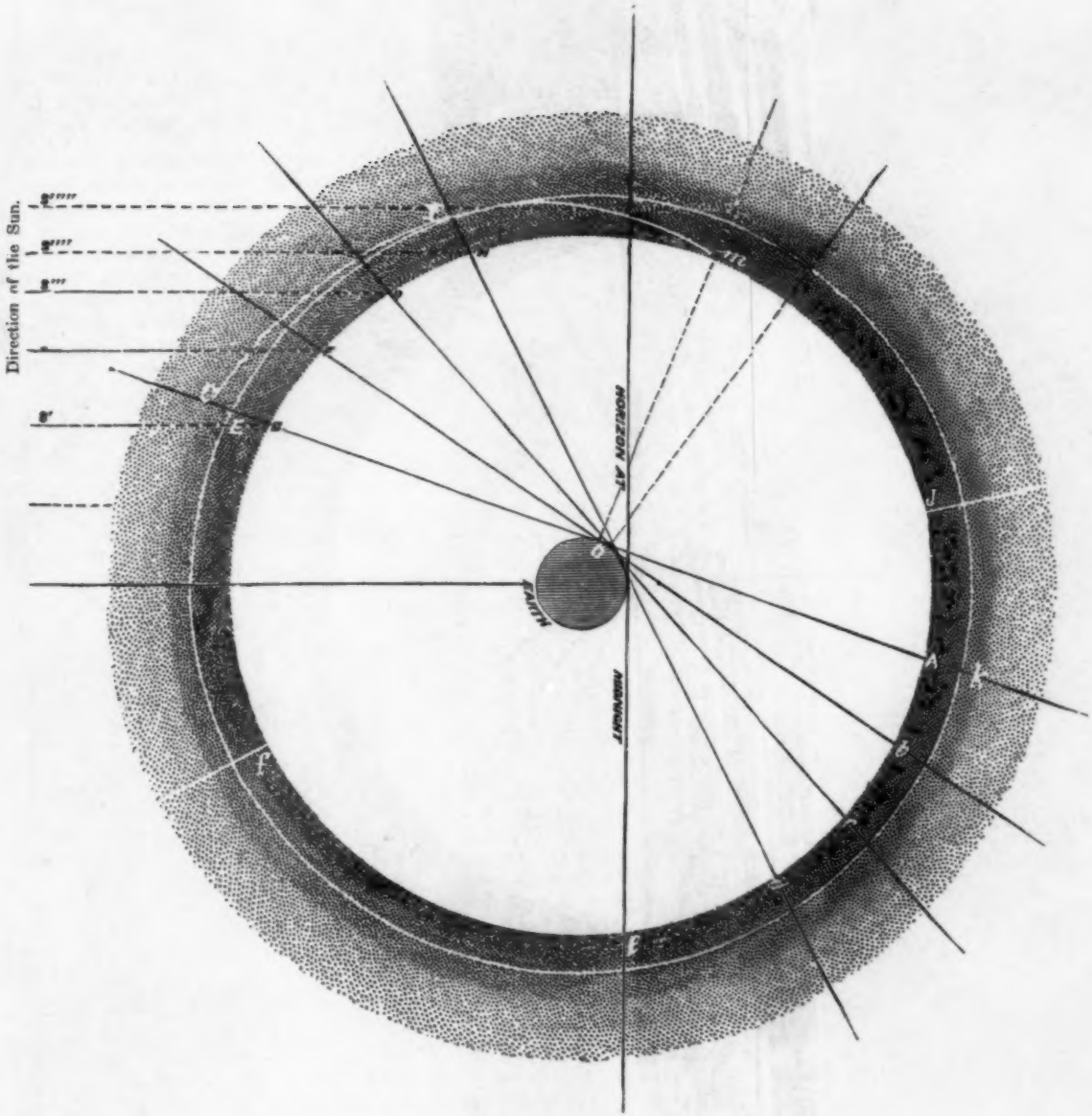


PLATE VI.

GEOCENTRIC NEBULOUS RING.



IV. ASTRONOMY.

1. *New Planets.*—The 43d (*Ariadne*) of the system of little planets between Mars and Jupiter, was discovered April 15, 1857, by Mr. Pogson at the Radcliffe Observatory, Oxford, Eng. Its apparent brightness was about that of a star of the ninth magnitude. The following elements have been computed by Mr. Pape from observations at Oxford, April 15; Altona and Liverpool, April 19; and Bilk, April 22:

Epoch, 1857, April 22·5, Berlin m. t.

Mean anomaly,	309° 16′ 23″·9
Long. of perihelion,	276 34 59 ·1
" " asc. node,	264 18 58 ·0
Inclination,	3 27 41 ·9
Angle of excentricity,	9 46 22 ·6
Log. semi-axis major,	0·343405
" mean daily motion,	3·034899

The 44th of this group was discovered May 27, 1857, by Mr. H. Goldschmidt, at Paris. Its brightness was that of a star of 10–11th magnitude.—*Astr. Jour., May* 30.

Another new planet was discovered June 27, 1857, by Mr. Goldschmidt at Paris.

2. *Second Comet of* 1857.—A comet was discovered, March 18, 1857, by Prof. C. Bruhns, of Berlin. It appeared as a small round nebula of 2′ diameter, with condensed nucleus, and without tail. Prof. B.'s computation seems to render it certain that this comet is identical with the third comet of 1846.—*Astr. Jour.*

3. *Third Comet of* 1857.—A telescopic comet of moderate brilliancy was discovered by Dr. Klinkerfues, at Göttingen, June 22, 1857.—*Astr. Jour. No.* 104.

4. *New Comet.*—A faint comet was discovered July 25, 1857, in the constellation *Camelopardalus*, by Dr. C. H. F. Peters, of the Dudley Observatory, Albany. The elements show that this comet is not identical with any of those expected to return this year.

5. *Zodiacal Light.*—In a recent paper read to the Royal Society by Professor Piazzi Smyth of Scotland, the author, after opposing the views of Rev. George Jones as published in his Japan Expedition Report, closes by saying, that he does not think Mr. Jones ever saw the zodiacal light at all. Surely this is a summary way of dealing with an author, and betrays no less arrogance than ignorance. We have compared observations at this place with those of Mr. Jones and know well his ability and fidelity in the investigation he has undertaken. It is true there is much to puzzle the theorist in the present state of the subject, but Prof. Smyth's way of sweeping the whole from science is a novel method of meeting the question.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *The Schuyler Tornado, Oneida County, New York.* (From the Utica Morning Herald of June 17th, signed W.).—On Saturday, the 13th inst., at about 4 P. M., we witnessed in our own neighborhood one of those terrific manifestations of power, a tornado. That it was an unmistakable tornado or whirlwind,—water spout, as it would have been had it occurred upon the surface of the water instead of the land,—there can be no doubt.

Many noticed about 4 P. M. of that day a peculiarity in the appearance of the clouds, which for the most part lay to the northward of us. At Whitestown, where it did not rain at all; in Marcy some eight miles west of the scene of the disaster, and in Utica, a peculiarity in the clouds to the east was noticed by different observers. One observer in Deerfield described the appearance as a huge cone like a hogshead in the clouds, and terminating far below in a point the size of a stove pipe, which passed along towards the east, two observers say as long as ten minutes, one says swaying to and fro as it passed. It was black like the cloud itself, and when it touched the ground its course was attended with a dense dust like a fog, so that no object could be seen near its apex, upon the ground. Observers who were within a few feet of it, as it passed along, describe its rate of speed as at least twice as fast as any railroad train, say sixty miles an hour; others who saw it from behind and could not judge so well, suppose that it moved much slower.

At Schuyler Corners the phenomenon was very intelligently and carefully observed by Dr. Mower. He as well as others saw it first nearly north of the Corners but a little west, then presenting the appearance of a huge cone, apex down, suspended by its base from the cloud, its lower point apparently twenty or thirty rods above the earth, and not more than forty rods from their position to a point directly under it. It passed on to the east lengthening as it went. Having passed out of sight from an intervening house, he changed his position for a moment to gain a new view, and when he again saw it, it had touched the earth. Its course was now attended with a huge cloud of dust, and he could no more see the apex of it. At one time, it swelled out in the middle, forming as it were two cones base to base, the apices above and below, and a smaller and similar cone separated from it towards the south; this second phenomenon was traced by its progress upon the earth as noticed further on. He says he saw it ten minutes, and it seemed to pass slowly along.

It first struck the ground just back of the little hamlet of Schuyler Corners, and commenced its progress of destruction by demolishing fences, marking a very sharply defined path by leaving a length of fence undisturbed even to the top rail, while the next length were scattered; trees of various kinds were uprooted, and at length a barn upon the first road leading north from the turnpike east of Schuyler Corners, was struck, unroofed, and its boarding removed, leaving the frame apparently undisturbed.

Here the branch whirlwind appears to have diverged from the main tornado and marked its course by demolishing the well-house and four apple trees directly through the centre of an orchard leaving all the rest untouched. The well-house and all the trees were thrown towards the north, thus demonstrating the gyratory character of this smaller storm.

But the main storm passed on in its terrible path, not only demolishing fences, but even sweeping off thistles, elders, and the young oats now like grass without stalk. From observations made upon these herbs it was easy to notice that the course of the tornado was not only forward in a direct south-southeast course, but was also gyratory, revolving about its own center from the south around toward the east, thence around towards the north, thence directly contrary to the general direction of the storm towards the west, thence back again towards the south. Persons conversant with such matters will comprehend us better when we say that it revolved in a direction contrary to the sun or the hands of a watch.

But at length it struck Mr. Warren's dwelling. This apparently was a well built story-and-a-half frame house about sixteen by twenty-four feet; its sills of hewn beech eight by ten inches; its plates also hewn and of good dimensions, and altogether a well built frame house. It was lifted off its foundation, striking upon its roof; its west side now lying upon the east of this inverted house, is torn from the rest of the structure and driven fifty feet farther across the road, while the house itself is rolled farther over upon what was its west side and now lies with its east side upon the top, so flat that a dog could not crawl under it. This is sixty feet from the foundation, and among its ruins lie the furniture of the house. A heavy cooking stove lies turned over twenty-six feet from its old position. This no doubt broke through the side of the house or fell through some window or door in the progress of the house. More than one hundred feet from the site of the building lies the west side of the house before mentioned, and near it the sill, probably the west one, thirty feet long, eight by ten inches in size, hewn from beech wood!

But tremendous as the power must have been to accomplish so much, it next demonstrated its ability to do more. A few rods beyond Mr. Warren's demolished house, directly in the course of the storm, were two large apple trees, one of them a sturdy old tree larger than a man's body, say sixteen inches in diameter or three feet in circumference. This was not uprooted, but *twisted off at the root*, leaving no bigger hole in the ground than a bushel of earth would fill up again, and transported through the air, leaving no furrow or mark upon the sward, fifteen feet to the south, and laid down in a direction south-southeast, precisely in the line of the storm; the other, a somewhat smaller one, was treated in a precisely similar manner, affording fresh evidence of the gyratory character and direction of the storm. I estimate that two tons would be a low figure for the weight of this large apple tree. Two other apple trees on the edge of the storm, thirty feet north, were simply uprooted, and lie, one, the top towards the south, the other towards the southwest. I do not believe they were blown down by the tornado, but by the wind rushing in to fill the vacuum which the tornado left behind it, and the existence of which is more strongly proved by a phenomenon to be noticed farther on.

But the climax of the storm is yet to be seen. About three hundred feet directly south-southeast of the apple trees, upon an abrupt eminence say thirty feet high, there stood a first class farmer's barn, thirty-five by fifty feet, with a stone foundation, and with posts sixteen feet high. Its length was east and west, and its roof sloped towards the north and to-

wards the south. The south portion of the roof was carried north over a garden with fruit trees and deposited in a field beyond, some portion 200, some 300, and a large portion at least 500 or perhaps 600 feet from the barn; while the north side was carried just about as far towards the south. A threshing machine of iron and wood, said to weigh 400 pounds, was carried 230 feet south-southeast, and a sill or plate of the barn, weighing probably twice as much, lies near it, while huge timbers are beyond it, one 300 feet to the south, nine inches square by twelve feet long. Thus for 500 feet or more all around towards the north, east and south of this barn, lie its fragments, every timber and board removed from the greater portion of the foundation, and even the two inch hemlock plank floor of the basement of the west end of the barn, saturated with water, any one of them a load for two men, are lifted up and thrown together in a heap. This it must be understood is at the bottom of the basement some ten feet deep, protected by the stone foundation wall as it should seem from the direct action of the wind. Their removal can only be accounted for by the principle before alluded to, that the gyratory and probably upward motion of the wind produced a vacuum which the air below the basement floor rushed up to fill, raising the plank with it.

Beyond this, at the distance of a quarter of a mile, in the field, stood a slighter barn, technically a hay barn. Not one timber stands upon another of this barn, nor can any considerable portion be seen at all, to such an extent is it scattered.

But with the exception of a forest tree or so twisted off or stripped of its leaves, and fences demolished, no more mischief was done, and at the distance of less than a mile from the house of Mr. Warren this fearful visitant left the earth. Its destructive progress probably did not exceed two and one-half miles in extent, but was uncertain in width. Those living in the neighborhood do not place its width at over fifteen rods, and we should be inclined to think that except at the large barn where it seemed to expand its fury, its width was much less, say sixty feet. We saw no signs of electricity, and suppose that the twisted thistles and elders and leaves withering in the sun, gave all the evidence that any seemed to have of the existence of any such agent in the storm. It was unattended with thunder or lightning or much rain, but accompanied, as some say, with a little hail.

[In another account of this tornado, in the Utica Morning Herald of the 15th of June, it is stated that the whirlwind was not accompanied by any wind or storm, a fact to be especially noted; "it seemed like an independent agency, traveling on its own account;" and it states also that in its own intestine motion there was a constant revolution. The absence of wind around and the very narrow track of destruction as well as the abrupt boundary of this track, are much against a common notion that whirlwinds are made by a rush of air towards a centre from the region around it. The moving power, both of rotation and onward progress were not below but above. Moreover it is stated that the trees along its path, not uprooted, were left "green and healthful in the bud," with no mark of heat or any of the usual effects of electricity. We once observed a whirlwind of similar character but of miniature size in he Middle Pacific with no land in sight to produce eddies in the atmos-

phere. The day was bright and sunny, and the ship lay becalmed. The whirl appeared, half a mile to a mile off, as a very narrow column reaching from the cloud above to the water. But as it moved, it would seem to lose its hold on the waters, and disappear for want of vapor to render it visible,—and then again it formed its column anew as again it reached to the water's surface: and so it went dancing along over the ocean. From this marching on of a rapidly rotating whirlwind in a calm, it was evident at the time that whirlwinds were due to a motive power more or less independent of the lower atmosphere around them. It was evident in that calm unbroken sea that corners of streets or obstacles of rocks or mountains were not required to make whirlwind eddies. The small whirl was manifestly a type of the great tornado, for throughout nature the small and great have a common law, and the law is often best read by us in the small.—J. D. D.]

2. *Examination of a Nickel Meteorite, from Oktibbeha County, Mississippi;* by Wm. J. Taylor, (Proceedings of the Acad. of Nat. Sci. of Philad., April, 1857.)—This highly interesting and unique meteorite was found in an Indian mound in which excavations were being made in a search for Indian antiquities, in Oktibbeha County, Mississippi. It then weighed five and a quarter ounces; in shape it resembled a hen's egg. When found, there was a fissure which divided it almost equally into two parts. The person who discovered it seeing this, placed it upon an anvil, and with one blow of a sledge-hammer, divided the meteorite. One half was forged, with the intention of manufacturing it into a cutting instrument of some description; the other remained in its original state, excepting that its exterior was filed smooth and bright.

To Dr. William Spillman, of Columbus, Mississippi, I am indebted for material for this investigation; he obtained the meteorite from the man who first found it. The unforged half he brought with him on a recent visit to this city, and a portion of which he has presented to the Academy, on the condition that it should be carefully cut, so that the surface which formed one side of the existing fissure above mentioned should be preserved and sent to him. It was proposed to have it cut by a lapidary, but he attempted it without success, using diamond dust on the wheel. On making the first incision, about one-eighth to one-sixteenth of an inch in depth, he found it impossible to proceed, and refused to make farther attempts to cut the meteorite. Mr. John Phillips, a fellow member of the Academy, and an amateur machinist, on hearing of our difficulties, kindly offered to saw the specimen, and succeeded admirably, though it was with very great difficulty. He spoke of its peculiar toughness, (the hardness not being excessive;) it resisted the saw very much, which rendered the cutting exceedingly tedious, heating the saw to such a degree as to oblige a discontinuance of the operation every four or five minutes, but it was remarkable that it did not dull the blade in the least.

The toughness of the iron was clearly shown when, for the purpose of analysis, it was attempted to cut off portions of it with a chisel; the excessive toughness of the iron rendered this very difficult, without the aid of the saw. The resistance of this meteorite to the action of acids was most remarkable. Strong nitric acid did not act upon it in the cold. Moderately dilute sulphuric acid did not act upon it. Strong and boiling hydrochloric acid acted upon it very gradually.

The above named acids failing to show the slightest trace of the Widmannstättian figures; a mixture of nitric acid and hydrochloric was used, boiling, but even after this operation no trace of them could be distinguished. The action of the aqua regia was gradual and peculiar, producing on the polished surface of the meteorite very small holes, varying in size from a pin's point to those as large as a pin's head. From the appearance of the surface of the meteorite, which formed a side of the fissure before described, I had hoped to obtain by etching beautiful Widmannstättian figures, as there is on this portion indistinct traces of that which would at first glance be called a crystalline structure.

The color of the metal is a silvery grey with a pinkish tinge. Its hardness is not excessive, yielding readily to the file. The tensibility, as before mentioned, was very great. The passivity was proved by testing it with a neutral solution of the sulphate of copper.

The specific gravity at 25° Cels., was found by Dr. F. A. Genth to be 6·854, which is too low, but owing to the numerous fissures through the meteorite filled with limonite, it was impossible to obtain the exact specific gravity of the metal. I used particular care to obtain a portion free from the flaws, but without effect. I take this opportunity to express my thanks to Dr. Genth for allowing me the use of his laboratory in making the examination. The following is the result of my analysis:

1·9421 grammes were dissolved in aqua regia.

1·4731	grams.	NiO	gave of	Nickel	59·69 per cent.
1·0452	"	Fe_2O_3	"	Iron	37·69 "
0·0221	"	CuO	"	Copper	0·90 "
0·0072	"	Al_2O_3	"	Aluminium	0·20 "
0·0105	"	Co_6O_7	"	Cobalt	0·40 "
0·0048	"	SiO_3	"	Silicium	0·12 "
0·0069	"	$2MgO, PO_5$	"	Phosphorus	0·10 "
0·0059	"	CaO, CO_2	"	Calcium	0·09 "
					99·19

The slight loss of eight-tenths of one per cent I think is owing to some small portions of limonite existing in the minute fissures already mentioned.

The 0·10 per cent of phosphorus correspond to 0·64 per cent of schreibersite, ($P Ni^2 Fe^4$).

It was first attempted to dissolve in hydrochloric acid, but the action of the acid, even when boiling, was so very gradual that nitric acid was added.

I endeavored to separate the nickel and cobalt by Liebig's new method, viz., by precipitating the nickel as a sesquioxyd, by passing chlorine through an alkaline solution of the two metals in hydrocyanic acid and potash, but it was found not to answer; the separation was made by his former method by oxyd of mercury.

The composition of this remarkable meteorite is in itself sufficiently interesting for mineralogists, without any attempts to account for its origin, either terrestial or celestial. We must remain in doubt as to the exact locality where it was originally found, as it may have been carrried by the Indians from a distance to be entombed in this mound, and it may

have been considered by them to have a special value, and possibly to possess peculiar virtues, from its being discovered in such a place.

3. *Meteoric Iron of Mexico.*—Meteoric iron from near Xiquipilco has been described and analyzed by Dr. Evan Pugh as follows (Ann. der Ch. u. Pharm., xcviii, 383, from his Inaug. Dissert. Göttingen, 1856).

No. 1. A piece of a specimen weighing 200 pounds. It has a thick crust of oxyd, in which are many yellow metallic spots of schreibersite. There are also yellow drops of the chlorid of iron. Texture within, coarse foliated, crystalline with large crystalline figures like the iron of Elbogen. Not passive. Yields sulphuretted hydrogen with dilute muriatic acid showing that it contains magnetic pyrites. Different trials showed that it contained 0·9 to 1·24 per cent of black insoluble material, consisting of phosphuret of nickel and iron, graphite, and microscopic grains of a yellowish colorless mineral.

No. 2. Specimen weighing 19½ lbs. Less oxydized than the preceding. Contains spots of schreibersite and also shows the yellow chlorid of iron in drops. In its interior there are greenish grains of *olivine*. Hardness greater than in the preceding. Texture broad crystalline, showing large figures. Not passive. No sulphuretted hydrogen with hydrochloric acid. Insoluble residues 0·568 to 1·58 p. c. consisting of schreibersite, graphite and grains of a colorless, a ruby red, and a greenish mineral.—Analyses:

		Fe	Ni	Co	P	Mn	S	Cu, Sn	Sch'site.	Graphite, &c.
I.	*a.*	90·43	7·62	0·72	0·15	——	0·03	0·03	0·56	0·34=99·88
	b.	90·08	7·10	——	——	——	1·24			
II.	*a.*	87·89	9·06	1·07	0·62	0·20	——	*trace*	0·34	0·22=99·41
	b.	88·28	8·90	1·04	0·78					
	c.	87·88	8·86	0·89	0·86					1·24

The oxydized crust consists of

Fe	Ĥ	S̈i	Ä̈l	Ṁg	Fe	Ni	Co	P	Schreibersite.
51·49	13·27	7·47	0·79	0·21	20·51	4·13	0·40	0·18	0·66=99·11

4. *Meteoric Stone.*—A meteoric stone fell on the island Oesel on the 11th of May, 1855, and is described by A. Göbel (Pogg. xc, 642). Specific gravity 3·668. Magnetic part 13·07 p. cent, containing nickeliferous iron 12·75, FeS 0·25, insoluble chromic iron 0·04, soluble chromic iron 0·01, phosphuret of iron and tin, 0·01. Non-magnetic part 86·93 p. c.; of which 46·86 is soluble in muriatic acid, and affords Olivine 41·13, sulphuret of iron 5·59, chromic iron 0·11, phosphuret of iron 0·03; 40·08 p. c., insoluble in muriatic acid, affords labradorite and hornblende 38·88, insoluble chromic iron 0·40, soluble chromic iron, phosphuret of iron 0·23. There is a trace also of manganese, cobalt, carbon, sulphur.

A fall took place near Civita Vecchia, in the sea, Sept. 17, 1856, near 10½ p. A. M. It was of large size, had a long trail and made a loud sound as it struck the water.

5. *Meteoric Stone.*—A meteoric stone fell near Bremervörde on the 13th of May, 1855, which broke into many pieces, the largest of them weighing 25 pounds, 29 loth, according to Wöhler (Ann. d. Ch. u. Pharm., xcix, 244). It has a thin crust and is grayish within. Composition:

Fe 21·11, Ni 1·89, S̈i 45·40, Ṁg 22·40, Ḟe 4·36 Ä̈l 2·34, Ṅa 1·18, K̇ 0·37, chromic iron 0·30, graphite 0·14, Co, P, Ca, Ṁn *traces* =100. The Ḟe was estimated from the loss.

6. *Meteoric Stone.*—A stone fell in East Flanders a German league from Gent on the 7th of June, 1855 at 7¾ hours in the evening. A piece of it procured by Mr. Duprez weighed 700·5 grams. Specific gravity 3·293.—*Pogg.* xcix, p. 64.

7. *Cabinets of Minerals for sale.*—Dr. F. A. Genth of Philadelphia offers for sale a valuable collection of minerals containing nearly 3100 specimens, among which he states there are many beautiful and rare crystallizations. Prof. Keating's cabinet, advertised a year since as on sale, is still in the hands of Dr. Genth, and could be had for $1000. The attention of colleges and other institutions to these cabinets is commended.

Dr. Genth also states that he has another mineral collection of small size, containing 700 specimens one and a half inches by two in size, which may he purchased for $175. And in addition, a collection of geological and palæontological specimens, 2500 in all, which he brought with him from Europe.

8. *Ray Society, (established* 1844) *for the publication of works on Natural History.* Subscription, one guinea a year.—The Council of the Ray Society, feeling that the objects it has in view are not sufficiently known, beg to call attention to the circumstances which gave rise to its existence. For many years previous to 1844, naturalists had felt the necessity of combining for the distinct purpose of bringing out some of the more important works on natural history, which existing societies could not publish, and which would not be undertaken by any publisher. It was also felt very desirable to reproduce some of the older standard works of British naturalists, and, by translation, to introduce to the British public the more important works on natural history published on the continent, more especially in Germany. For the accomplishment of these objects, the Society commenced its labors in 1844, and has since published the following works:

For the first year, 1844.—I. Reports on the Progress of Zoology and Botany; translated by Hugh E. Strickland, Jun., Esq., M.A., F.R.S., E. Lankester, M.D., F.R.S., and W. B. Macdonald, Esq., B.A. 8vo, pp. 498.

II. Memorials of John Ray: consisting of the Life of John Ray, by Derham; the Biographical Notices of Ray, by Baron Cuvier and M. Dupetit Thouars, in the Biographie Universelle; Life of Ray, by Sir J. E. Smith; the Itineraries of Ray, with Notes by Messrs. Babington and Yarrell; edited by E. Lankester, M.D., F.R.S. Frontispiece. 8vo, pp. 230.

III. A Monograph (with colored drawings of every species) of the British Nudibranchiate Mollusca; by Messrs. Alder and Hancock. Part I. Imp. 4to.

For the second year, 1845.—I. Steenstrup on the Alternation of Generations; translated from the German by Geo. Busk, Esq., F.R.S. Three plates. 8vo, pp. 132.

II. A Monograph of the British Nudibranchiate Mollusca, with thirteen colored illustrations in litho-tint; by Messrs. Alder and Hancock. Part II. Imp. 4to.

III. Reports and Papers on Botany, consisting of translations from the German; translated by W. B. Macdonald, Esq., B.A., G. Busk, Esq., F.R.S., Arthur Henfrey, Esq., F.R.S., and J. Hudson, Esq., B.M. Seven plates. 8vo, pp. 494.

For the third year, 1846.—I. Meyen's Geography of Plants; translated from the German by Miss Margaret Johnston. 8vo, pp. 422.

II. Burmeister on the Organization of Trilobites, with six plates; translated from the German, and edited by Professors Bell and E. Forbes. Imp. 4to, pp. 136.

III. Alder and Hancock's British Nudibranchiate Mollusca, with 11 colored plates in litho-tint. Part III. Imp. 4to.

For the fourth year, 1847.—I. Oken's Elements of Physio-Philosophy; translated from the German, by Alfred Tulk, Esq.

II. Reports on the Progress of Zoology; translated from the German, by George Busk, Esq., F.R.S., A. H. Halliday, Esq., and Alfred Tulk, Esq. 8vo, pp. 680.

III. A Synopsis of the British Naked-eyed Pulmograde Medusæ, with 13 colored plates, drawings of all the species; by Professor E. Forbes, F.R.S. Imp. 4to.

For the fifth year, 1848.—I. Bibliographia Zoologiæ et Geologiæ; by Professor Agassiz of Neufchatel, edited by Hugh E. Strickland, Esq, M.A., F.R.S. Vol. I. 8vo, pp. 506.

II. The Letters of John Ray; edited by E. Lankester, M.D., F.R.S. Two plates. 8vo, pp. 502.

III. Alder and Hancock's Nudibranchiate Mollusca, with colored illustrations. Part IV. Imp. 4to.

For the sixth year, 1849.—I. Reports and Papers on Vegetable Physiology and Botanical Geography; edited by A. Henfrey, Esq., F.R.S. Three plates. 8vo, pp. 514.

II. A Monograph, with 36 plates (mostly colored), of all the species, of the British Entomostracous Crustacea; by Dr. Baird, F.L.S. 8vo, pp. 364.

For the seventh year, 1850.—I. Vol. II of the Bibliographia Zoologiæ et Geologiæ. 8vo, pp. 492.

II. Part V of Alder and Hancock's Nudibranchiate Mollusca, with 15 plates, 12 colored. Imp. 4to.

For the eighth year, 1851.—I. A Monograph of the British Angiocarpous Lichens, with 30 colored plates; by the Rev. W. A. Leighton, M.A. 8vo, pp. 100.

II. A Monograph, with 10 copper-plates and other illustrations, of the Family Cirripedia; by C. Darwin, Esq., M.A., F.R.S. Vol. I. 8vo, pp. 400.

For the ninth year, 1852.—I. Vol. III of the Bibliographia Geologiæ et Zoologiæ. 8vo, pp. 657.

II. Part VI of Alder and Hancock's Nudibranchiate Mollusca, with 12 plates, 11 colored. Imp. 4to.

For the tenth year, 1853.—I. Vol. II of Darwin's Monograph on the Cirripedia, 30 plates. 8vo, pp. 684.

II. A volume of Botanical and Physiological Memoirs, including Braun on Rejuvenescence in Nature, 6 plates, colored. 8vo, pp. 568.

For the eleventh year, 1854.—Vol. IV of the Bibliographia Geologiæ et Zoologiæ. 8vo.

For the twelfth year, 1855.—Part VII of the Nudibranchiate Mollusca, with nine plates, concluding the work; by Messrs. Alder and Hancock.*

* By a minute of Council, subscribers for 1854 and 1855 alone are entitled to select a volume in addition for each year from the past year's publications.

It will be seen that these works are not only valuable contributions to science, but that some of them are unequalled in the literature of natural history; and although an ample return to the members for their guinea subscriptions, the Council could have increased both their number and value had the funds at their disposal enabled them to do so.

The subscribers to the Society have never yet exceeded 1000 members, and as the Council are continually obliged to defer the publication of valuable works, on account of their limited resources, they hope that by bringing the claims of the Society more prominently before naturalists and the patrons of science, they may thereby meet with encouragement to widen the field of their labors.

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(2.) On the Oceanic Hydrozoa, by T. H. Huxley, Esq., F.R.S.

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(4.) General History of the Foraminifera, by Dr. Carpenter. 4to.

(5.) A Monograph of the British species of Spongiadæ, by J. S. Bowerbank, Esq., F.R.S.

(6.) A Monograph of the British Araneidæ, by J. Blackwall, Esq.

(7.) The Travels of Linnæus in West Gothland, translated by G. B. Lewin, Esq., M.A. 8vo.

(8). A Supplement and Index to the Bibliography. 8vo.

Whilst the Council feel that each of their members receives an equivalent for their subscription, they look also to support from those who would be glad to assist in a great scientific work, independent of any immediate benefit to be derived therefrom.

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II. Every subscriber of one guinea annually to be considered a member of the Society, and to be entitled to one copy of every book published by the Society during the year to which his subscription relates; and no member shall incur any liability beyond the annual subscription.

III. That the annual subscriptions shall be paid in advance, and considered to be due on the first day of January in each year; and that such members as do not signify their intention to withdraw from the Society before the second day of June, shall be considered to continue members, and be liable to the year's subscription.

9. OBITUARY.—*Prof. Elisha Mitchell.*—We are pained to announce the death of Rev. Dr. MITCHELL, Professor of Chemistry in the University of North Carolina. It occurred by a melancholy accident, among the Alleghany mountains, near the eminence which bears his name, on the 27th of June last. A few years since he had explored the lofty mountains lying in the western part of North Carolina, and had ascertained the height of a peak of the Black Mountain range, to be greater than any elevation east of the Rocky Mountains. It has since been called "Mount Mitchell," and is so denominated by geographers. Some discussion having arisen between him and the Hon. Mr. Clingman, respecting the relative heights of this and another mountain of the same range, he was at the time of his death engaged in a new measurement of those peaks, aiming at the same time to serve the cause of science, by establishing a series of levels in connection with a railroad survey in progress in that country. On the 27th of June, Dr. Mitchell had left his hotel alone, and on foot, intending to cross a wild region to a place about ten miles distant, where he was to join his son and daughter, who had accompanied him on the excursion. Not arriving at the appointed station, the alarm was spread, and after eleven days, his body was found in a river at the foot of a precipice from which he must have fallen, as was evident from a branch of laurel which was broken off and was still grasped in his hand.

Professor Mitchell was born in Washington, Conn., August 19, 1793, and graduated at Yale College, with distinction, in the class of 1813. He was tutor from 1816 to 1818, at which time he was elected Professor of Mathematics in the University of North Carolina. In 1825 he was transferred to the chair of Chemistry, Mineralogy and Geology. Having served the institution with faithfulness and ability for nearly forty years, and made valuable contributions to science, his death is deeply lamented. The State of North Carolina, especially, has evinced for him the highest degree of respect and affection, and is contemplating distinguished honors to his memory. O.

Prince CHARLES LUCIEN BONAPARTE the ornithologist, died early in August, aged 54 years; AUGUSTIN CAUCHY the mathematician, on the 23d of May at Paris, aged 78 years; THENARD the chemist, at Paris, in June last.

10. *Climatology of the United States*, and of the Temperate Latitudes of the North American Continent, embracing a full comparison of these with the Climatology of the temperate latitudes of Europe and Asia, and especially in regard to Agriculture, Sanitary investigations and Engineering, with Isothermal and Rain Charts for each season, the extreme months and the year, including a Summary of the Statistics of Meteorological observations in the United States, condensed from recent scientific and official publications; by LORIN BLODGET, author of several reports on American climatology; member of the National Institute and of various learned societies. 536 pp., large 8vo, with several maps. 1857. Philadelphia: J. B. Lippincott & Co. London: Trübner & Co. $4.00 in cloth.—The contents of this new volume on meteorology are given in the above cited title. It treats of the subjects in a comprehensive manner, embracing a large part of North America as its field, and bringing this great region into its place with reference to the globe. It aims especially to present the geography of temperature and

of rain and snow for temperate North America; and besides discussing the peculiarities of the different parts of the country east and west, north and south, it illustrates the distribution by large and neatly made charts like those of Berghaus's great work, republished in Johnston's Physical Atlas. These charts are, an isothermal chart for each of the four seasons, and one for the year; and the same number of "hyetal" or rain charts. In addition to these there is a temperature and a hyetal chart for the whole north temperate zone of the globe. The charts relating to the United States are very similar to those published in the Army and Meteorological Register in 1855, which work has been noticed in this Journal. They have undergone however some important modifications from the collection of more recent facts; yet of course can now only claim to express the present state of knowledge on the subject.

We have not space at this time to discuss or present the views or conclusions brought forward by the author, or to attempt any special verification of his lines of temperature and rain regions. Science owes much to his labors. The work is greatly in advance of any hitherto published on American climatology. His descriptions and charts are full of instruction and go far towards enabling us to comprehend the nature of the grand system of atmospheric temperature, winds and moisture.

Mr. Blodget, besides enjoying the advantages derived from his connection with Dr. Coolidge in the collation and study of the army meteorological observations, was also for a while in charge of the meteorological department in the Smithsonian Institution; and to both of the sources of facts here mentioned he is largely indebted for the means of preparing this important survey of American climatology. The publishers have issued the volume in excellent style and at a very low rate for a work so large and so well illustrated.

11. *Explorations in the Dacota Country in the year* 1855; by G. K. Warren, Topographical Engineer of the Sioux Expedition, 80 pp. 8vo. Washington, 1856. Exec. Doc., No. 76, 34th Congress, 1st Session.—The Government Explorations of the Rocky Mountain Slopes are adding much to science as well as general geography. Lieut. Warren's Report, is mainly topographical, but gives also information on the distribution and peculiarities of the Indians of the Dacota Country, some geological observations, and important meteorological tables. It closes with a sketch of some of the geological and physical features of the region of the Upper Missouri, with notes on its soil, vegetation, &c., by F. V. Hayden.

12. *Maury's Wind and Current Charts; Gales in the Atlantic.* Pamphlet in 4to, of 24 charts. Observatory, Washington, May 1857.—This quarto pamphlet by Lieutenant Maury, consists of a series of charts of the North and South Atlantic, exhibiting by means of colors the prevalence of gales over the more stormy parts of the oceans, for each month in the year. One color shows the region in which there is a gale every 6 days, another color every 6 to 10 days, another every 10 to 14 days, and there is a separate chart for each month and each ocean. The author observes that this is the first attempt to delineate the rain regions over these oceans, and that although the result has cost much labor it is necessarily imperfect in consequence of the few observations as data on which he has had to rely. It is an initial step in an important work.

13. *Smithsonian Report for* 1856.—The Annual Report of the Smithsonian Institution for 1856, contains, besides other details, a report on the progress of the Zoological Museum, which has increased in six years from almost nothing to about 12,000 species, mostly from the Government Surveying Expeditions through the west, and the labors of Prof. S. F. Baird; also abstracts of the lectures delivered before the Institution during the year; a paper by Prof. Henry on the mode of testing building materials; a continuation of a Report on the Progress of Physics, besides other scientific papers.

14. *Proceedings of the American Association for the Advancement of Science.* 10th Meeting, held at Albany, New York, August, 1856. 260 pp., 8vo, Cambridge, 1857. Published for the Association by Joseph Lovering, Permanent Secretary.—The American Association is greatly indebted to Prof. Lovering for the care he has bestowed in the printing and publication of the proceedings.

15. *Eleventh Meeting of the American Association.*—The eleventh meeting of the American Association for the Advancement of Science opened at Montreal on Wednesday, the 12th of August last. The president elect, Professor J. W. Bailey, having died during the year, the vice president, Professor Caswell of Brown University, was the acting President. The number of members in attendance was as large as at any previous meeting. Mr. Ramsay was received as delegate from the Geological Society of London, and Mr. B. Seeman, from the Linnæan Society of London. The departments of astronomy, physics, meteorology and geology, were well represented by papers, and especially the last, and there were also important communications in ethnology; while in zoology, botany, and chemistry, the communications were exceedingly few. A biographical memoir of Mr. William C. Redfield, the first president of the Association, was read by Professor D. Olmsted, and one of Professor Bailey, by Dr. A. A. Gould of Boston. The retiring President, Prof. James Hall, delivered an address on American Geology.

Commodious accommodations for the meetings, were afforded the Association, at the Court House, by the government of Canada, and generous attentions by citizens of Montreal. Each member was furnished on arrival with a large folded card, containing, on one side, a plan of the Court House, a list of the officers of the Association, and an enumeration of the places of public interest in and about Montreal, and on the other, a map of the city of Montreal and of the St. Lawrence adjoining with its islands, and also a colored geological map of Canada for a circuit of fifty miles around Montreal, showing the outlines of the formations as laid down by Sir William E. Logan, under whom the geological survey is still in progress.

One of the principal objects of attraction in the city, was the Geological Museum, containing the collections made in the course of this survey. It was remarkable for the extent and variety of rock-specimens, and the great number and beauty of the fossils; no geological survey on this or any other continent has been carried forward with greater energy or skill.

The following is a list of the papers presented at this meeting. As in other cases, we publish no abstracts of papers read, except such as may be furnished us by the authors. The Edinburgh Philosophical Journal

the past year has done injustice to many authors, by making citations from the newspaper reports of the papers read at the Albany meeting.

I. *Mathematics, Physics, Meteorology, and Chemistry.*

On the Zodiacal Light; by Charles Wilkes, U. S. N.

Observations on the Zodiacal Light at Quito, Ecuador, with deductions; by Rev. Geo. Jones, U. S. N.

On the Vibrations of the Fall over the Dam at Holyoke, Mass.; by E. S. Snell.

Hypothesis concerning Meteoric Stones; by Robert Burns.

Notes on the measurement of a base line on Epping Plains, Washington county, Maine, for the Primary Triangulation of the eastern section of the coast of the United States; by A. D. Bache.

On the Winds of the Pacific Coast of the United States; by A. D. Bache.

On the heights of the Tides of the Atlantic coast of the U. States; by A. D. Bache.

Solar Eclipse of March 14–15, 1858; by Thomas Hill.

A note on Arithmetical Complements; by Thomas Hill.

On a System of Co-ordinates in Analytic Geometry; by Thomas Hill.

Note on the Gyroscope; by B. Peirce.

Note on the Conservation of Force; by B. Peirce.

On the diverse Weights employed in modern Coinage; by J. H. Gibbon.

On a new source of Electrical Excitation; by Mrs. Elisha Foote.

On the physical conditions determinate of the climate of the United States; by Joseph Henry.

On some Phenomena of Ice; by Joseph Henry.

On the influence of the Gulf Stream upon the Climate of the Atlantic coast of the United States; by Dr. James Wynne.

On the application of a new arrangement of Locomotive Boiler, to the combustion of Coal; by Dr. James Wynne.

On the warped surfaces occurring in Road Excavations and Embankments; by W. M. Gillespie.

Preliminary Researches on the alleged influence of Solar Light on the Process of Combustion; by John LeConte, of South Carolina College.

On some special relations of the Straight Line and the various orders of Curves; by Stephen Alexander.

Of the Special Harmonies of the Distances and the Periodic times of the bodies composing the Solar system, and the physical hypothesis to which this state of things seems to be referable; by Stephen Alexander.

Some farther statistics and inquiries with respect to the form, magnitudes, &c., of the Asteroid Planets; by Stephen Alexander.

Some of the phenomena of the Texas "Norther" and Climatology; by G. C. Forshey.

Improvement in the construction of the Achromatic Telescope; by H. L. Smith, Kenyon College, Gambier, O.

On an improved construction of Ruhmkorff's Induction Apparatus; by E. S. Ritchie.

On the Electrical Hypothesis of the Aurora Borealis; by D. Olmsted.

Some observations respecting a Steam-boiler Explosion at Haverhill, Mass.; by James R. Nichols.

On a series of new Meteorological and Physical Tables prepared for the Smithsonian Institution; by A. Guyot.

On the Barometric formulæ for the measurement of differences of level by the Barometer, and a proposed modification of Laplace's Constant; by A. Guyot.

On the idea of Physical and Metaphysical Infinity; by E. B. Hunt, Lieut. U. S. Engineers.

Memoir on the Molecular Constitution of Material Masses; by E. B. Hunt, Lieut. U. S. Engineers.

Paper on Weights and Measures; by G. M. Dexter.

On a new Electro-magnetic Governor for Uniform Motion; by J. H. Lane.

Sketch of a plan proposed for reducing observations upon periodical Phenomena to a series of mean dates, and the advantages of this method of developing the Laws of Climate; by Franklin B. Hough.

On Ozone; and on the Meteorology of Montreal; by C. Smallwood.

Lateral Pressure of Running Water; by Thomas Green.

On a new Maximum Thermometer; by Thomas Green.

On a new method of Determining the Commercial value of Saltpetre; by E. N. Horsford.

An enquiry into the causes of a peculiar discoloration of Coffee, which had been stored in the same building with Guano; by Dr. Lewis H. Steiner.

II. *Geology and Natural History.*

On the Flexures of the Strata in the Broadtop Coal Field, Pennsylvania; by J. P. Lesley.

On Comparative Sections in Western Kentucky, and Western and Eastern Pennsylvania; by J. P. Lesley.

On the Variety and Preservation of the Sternbergia; by J. W. Dawson.

On the Newer Pliocene Fossils of the St. Lawrence Valley; by J. W. Dawson.

On the division of the Azoic Rocks of Canada into Huronian and Laurentian; by Sir W. E. Logan.

On the probable subdivision of the Laurentian series of Canadian Rocks; by Sir W. E. Logan.

On the relative dates of the various intrusive Rocks, cutting the Laurentian Series in Canada; by Sir W. E. Logan.

On some Mineral Waters, and on the origin of Magnesian Rocks; by T. S. Hunt.

On the Parallelism between the rocks of the Laurentian and Silurian Systems; by T. S. Hunt.

On some intrusive rocks of the District of Montreal; by T. S. Hunt.

General Considerations on the Metamorphism of the Sedimentary Rocks; by T. S. Hunt.

On a subsidence on the Coast of New Jersey and some of the adjoining States; by Geo. H. Cook, Rutger's College.

Notice of a New System of Dressing Metallic Ores; by B. Silliman, Jr.

On some Debatable Points in Natural Science; by E. J. Chapman, Toronto.

On a Species of Trilobite and Pleurotomaria from the Potsdam Sandstone of New York; by J. D. Dana.

On the General Plan and Mode of conducting the Geological Survey of Great Britain; by A. C. Ramsay.

On the Physical Break and the Break in the Succession of Life in the British Rocks; by A. C. Ramsay.

On the place in the Geological series of the masses of Crystalline or Sub-crystalline Stratified Rocks, in the North Highlands of Scotland; by Sir Roderick Murchison, with a Note on the Fossils by J. W. Salter.

On Graptopora, a new genus of Polyzoa allied to the Graptolites; by J. W. Salter.

On the Fluctuations of Level in the North American Lakes; by Chas. Whittlesey.

Notice of the occurrence of Chrysolite in Basalt; by O. P. Hubbard.

On the occurrence of Sharks' Teeth in the Drift of the Mississippi; by A. H. Worthen.

A critical review of the different Measurements of Mount Washington, in the White Mountains of New Hampshire; by A. Guyot.

On the Physical Structure of the Continent of Africa; by A. Guyot.

On the General Distribution of Large Forests on the Globe as connected with certain Climatic conditions; by A. Guyot.

On the Direction of Ancient Currents of Deposition and the source of Materials in the Older Palæozoic Rocks, with Remarks on the Origin of the Appalachian Chain of Mountains; by James Hall.

On the Cretaceous formations of the United States and the North American Continent; by James Hall.

On the Carboniferous Limestones and Coal Measures of the United States; by James Hall.

On the comparative extent and distribution of the Limestones of the Palæozoic period, and the similarity of forms among fossils of the different epochs; with remarks upon the probability of different centres of distribution for the fauna of the same epoch; by James Hall.

Contributions to the Geology of California and the Gadsden Purchase: by T. Antisell.

On the occurrence of masses of Native Copper in the mineral veins of Point Keweenaw; by Chas. Whittlesey, Cleveland.

On the origin of Anthracite and Bituminous Coal; by C. Whittlesey.

Note on the Formation of Continents; by Benjamin Peirce.

Fossils of the Sandstones and Slates of North Carolina; by E. Emmons.

On the Age and Dip of the Connecticut River Sandstones, and the intercalation of the associated Trap; by Edward Hitchcock.

On Fractured Ledges of Slate in Vermont; by Charles H. Hitchcock.

Foot-Prints in the Texas Tertiary; by C. G. Forshey.

Explanations of the Geological Map of Missouri and a section of its Rocks; by G. C. Swallow.

Some observations on the Petrography of Gaston County, North Carolina; by Henry Wurtz.

New localities of Minerals observed in North and South Carolina, and especially upon the discovery of Nickel and Cobalt in quantity in Gaston County, North Carolina; by Henry Wurtz.

On the Parthenogenesis of Animals and Plants; by Berthold Seemann.

Marine Phosphorescence; by H. G. Warner, Rochester, N. Y.

On the functions of the Spinal Cord as manifested by experiments on cold-blooded Animals; showing that an animal is capable of perceptive movements after removal of the Cranium or Brain; by George Paton, M.D.

On the Structure of the Skull in Vertebrata; by T. C. Hilgard, M.D.

III. *Ethnology, Statistics, Political Economy, etc.*

On Arrow-head or Wedge Inscriptions; by J. H. McIlvaine.

On the Ethnological Bearings of certain Architectural forms; by J. P. Lesley.

On the word Celt; by J. P. Lesley.

On a Universal Language; by Hugo Reid.

Thoughts on Species; by James D. Dana.

On the supposed Uniformity of Cranial Type throughout all varieties of the American Race; by Daniel Wilson, Toronto.

Remarks on the Collection of Indian Paintings and Antiquities exhibited by Mr. Paul Kane, at the request of the Local Committee; by Daniel Wilson.

Remarks on the Classification of the Varieties of Man; by M. B. Anderson.

On the ancient mining operations of Lake Superior; by Charles Whittlesey.

The Behistun Inscription (Arrow-head); by J. H. McIlvaine.

Observations upon the Sanscrit Language; by J. H. McIlvaine.

The Laws of Descent among the Iroquois.—1st, Descent in the Female Line.—2d, Degrees of Consanguinity; by L. H. Morgan.

Comparison of the Religious System of the Iroquois with that of the Ancient Persians; by L. H. Morgan.

On the Law of Human Mortality obtaining in Massachusetts, with Tables of Average duration of Life, Life Annuities, and other practical monetary values; by E. B. Elliot.

Intensity of Mortality at different ages in Massachusetts, England, Sweden, Prussia, Belgium, and other communities compared; by E. B. Elliot.

Observations on the Manners and Customs of the Indians of the North West; illustrated by paintings executed by the author during his travels; by Paul Kane.

On some Ethnological Specimens from the Island of Aneiteum, New Hebrides; by J. W. Dawson.

On certain peculiarities of the Languages of Southern Africa; by J. Constantine Adamson.

On Bank Notes, and the means adopted for prevention of counterfeiting; by B. Silliman, Jr., Yale College.

On some modes of preventing the Counterfeiting of Bank Notes; by T. S. Hunt.

On certain ternary compounds,—Chromites—recently discovered; by A. K. Eaton.

On Surety Paper; by E. N. Horsford.

Views and suggestions on the practice and theory of Scientific Publication; by Lieut. E. B. Hunt, Corps of Engineers, U.S.A.

The Universal Science; by Clinton Rosenvelt.